The terms training manual (TRAMAN) and nonresident training course (NRTC) are now the terms used to describe Navy nonresident training program materials. Specifically, a TRAMAN includes a rate training manual (RTM), officer text (OT), single subject training manual (SSTM), or modular single or multiple subject training manual (MODULE); and a NRTC includes nonresident career course (NRCC), officer correspondence course (OCC), enlisted correspondence course (ECC) or combination thereof.

Although the words "he," "him," and "his" are used sparingly in this manual to enhance communication, they are not intended to be gender driven nor to affront or discriminate against anyone reading *Ocean Systems Technician 3 & 2 (Maintainer),* Module 2, *General Maintenance*, NAVEDTRA 062-02-45-88.

Naval Education And Training Program Management Support Activity

OCEAN SYSTEMS TECHNICIAN 3 & 2 (MAINTAINER)

MODULE 2

GENERAL MAINTENANCE

NAVEDTRA 062-02-45-88

1982 Edition Prepared by
OTC Fred C. Jaworsky

PREFACE

This Training Manual Module and Nonresident Training Course (NRTC) form a self-study package that will enable Ocean Systems Technicians to help themselves fulfill the requirements of their rating.

This Module is part of a series written for personnel who are specializing in the maintenance aspects of the Ocean Systems Technician (OT) rating.

Designed for individual study and not formal classroom instruction, this Module provides subject matter that relates directly to the occupational standards of the OT rating. The NRTC provides a way of satisfying the requirements for completing the Module. The assignment in the NRTC includes learning objectives and supporting questions designed to lead the student through the Module.

1982
Revised 1988

Stock Ordering No.
0507-LP-062-0205

Published by
NAVAL EDUCATION AND TRAINING
PROGRAM MANAGEMENT SUPPORT ACTIVITY

UNITED STATES
GOVERNMENT PRINTING OFFICE

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

module contents.

ANALYST

Module 1—The OT Rating, NAVEDTRA 052-01-45-86

This module reviews the career paths available to "OT" personnel and security regulations applicable to the rating.

Module 2—Physics of Sound, NAVEDTRA 052-02-45-81

This module provides information about sound travel through water and its effect on Lofar detections.

Module 3—Analysis, NAVEDTRA 052-03-45-81

This module provides training in basic Lofar Analysis, origins of detectable sound sources, and propulsion systems and signatures.

Module 4—Subsurface Acoustic Characteristics, NAVEDTRA 052-04-45-84

This module provides specific information on acoustic contacts including sound sources and characteristics.

Module 5—Contact Handling, NAVEDTRA 052-05-45-83

This module describes methods of contact classification, plotting and positioning, and reporting requirements.

Module 6—Operator Maintenance, NAVEDTRA 052-06-45-82

This module provides information on the routine maintenance conducted by analysts on assigned equipments.

Module 7—Ocean Systems Equipment Operation, NAVEDTRA A52-07-45-86

This module provides information on the operational characteristics of the various Oceanographic subsystems.

MAINTAINER

Module 1—The OT Rating, NAVEDTRA 052-01-45-86

This module reviews the career paths available to "OT" personnel and security regulations applicable to the rating.

Module 2—General Maintenance, NAVEDTRA 062-02-45-88

This module provides information on the use of publications, station drawings, and schematics, modular construction and soldering.

Module 3—Equipment Maintenance, NAVEDTRA 062-03-45-82

This module provides information on the various AN/FQQ front ends, a walk through of a typical system, special purpose test equipment, Recorder/Reproducer AN/USH-3(V)2, and PMS.

Module 4—Ocean Systems Computers, Processors, and Peripheral Equipment, NAVEDTRA 062-04-45-86

This module provides information on the technical and operational characteristics of both government-furnished and contractor-furnished equipment.

Module 5—Administration and Supply, NAVEDTRA 062-05-45-82

This module provides information on electronics administration and supply. The administration portion will cover maintenance of logs and records, and the relationship of a typical organization at the division level. The supply portion describes ordering of parts, inventory of equipment, and COSBAL.

Module 6—Oceanographic Subsystems, NAVEDTRA 062-06-45-86

This module provides information on the technical characteristics and equipment configuration of various Oceanographic subsystems.

GENERAL MAINTENANCE

INTRODUCTION

As an Ocean Systems Maintenance Technician, you will perform alignment and calibration procedures on a routine basis and carry out corrective measures to restore equipment to a fully operational status.

This module is designed to familiarize you with sources of available information and general guidelines for performing electronic maintenance. Before starting this module you should complete appropriate *Navy Electricity and Electronics Training Series (NEETS)* modules to provide you with a basic understanding of electrical and electronic subjects pertinent to your rating.

MAINTENANCE PUBLICATIONS

One of the most useful assets of a maintenance man is the ability to locate information on a subject through the use of reference materials. No single publication can give you all the maintenance duties of your rating. However, the various publications in your maintenance division's technical publications library should provide the guidance for most types of maintenance actions required. A few of these publications will be discussed below.

TECHNICAL MANUALS

Technical manuals are perhaps the most important books in a reference library because they contain authoritative information that is essential for proper operation, maintenance, apply. All Navy technical manuals are designed in accordance with a military specification that specifies how the book should be written and what it must contain.

For most electronic equipment, the technical manual covers the following equipment areas:

- General Information
- Operation
- Functional Description
- Scheduled Maintenance
- Troubleshooting
- Corrective Maintenance
- Parts Lists
- Installation

NAVAL SHORE ELECTRONICS CRITERIA HANDBOOKS

The Naval Shore Electronics Criteria Handbooks are a series of fifteen books promulgated by NAVELECSYSCOM to present an overview of the total Naval Shore Electronic System process, and to provide references to pertinent policy directives/instructions, criteria, and standards. The criteria presented in the series do not constitute detailed specifications for any particular facility or project, but are of sufficient depth and scope to address the major considerations for selecting, designing, installing, and support-

The series, assigned NAVELEX numbers 0101,101 through 0101,115, consists of the following titles:

- General
- Naval Communication Station Design
- HF Radio Propagation and Facility Site Selection
- HF Radio Antenna Systems
- Satellite Communications Systems
- Electromagnetic Compatibility and Electromagnetic Radiation Hazards
- Naval Aeronautical Facilities
- Naval Security Group Elements, Design and Performance
- Naval Training Facilities
- Installation Standards and Practices
- Digital Computer Systems, Volumes 1 and 2
- Microwave and Troposcatter Communication Systems
- Navy VLF, LF, and MF Communication Systems
- NAVELEX Calibration Program

Like other publications, the Naval Shore Electronics Criteria Handbook series is not intended to be the single reference, but is designed as a source of pertinent criteria which are not promulgated elsewhere and as a ready reference to other related sources.

ELECTRONIC INSTALLATION AND MAINTENANCE BOOK

authoritative publications which provide field activities with information pertaining to the installation and maintenance of electronic equipment. Information for the EIMB has been taken from such sources as the Electronics Information Bulletin (EIB), Naval Ship Systems Command Technical News, notices, and instructions. It supplements equipment technical manuals and related publications, and is intended to reduce time-consuming research.

The EIMB series handbooks are divided into two main categories: general information handbooks and equipment-oriented handbooks.

There are seven general information handbooks in the EIMB series and the information contained in them is of interest to all personnel involved in electronic equipment installation and maintenance. These handbooks are discussed in the following paragraphs.

The *General Handbook* (NAVSHIPS 0967-LP-000-0100) can be considered an introduction to the entire series. It describes the contents of the other general information handbooks; provides an index to various EIMB handbooks; and covers such subjects as safety, administrative procedures, an index to EIB articles, and information related to publications and their handling.

The *Installation Standards Handbook* (NAVSHIPS 0967-LP-000-0110) was prepared to promulgate approved shipboard installation standards, techniques, and practices of NAVSHIPS electronic equipment. The subjects covered include equipment handling, location, and mounting; interconnection cabling and wiring; transmission lines; antennas and detection devices; and information on welding, soldering, and brazing.

The *Electronic Circuits Handbook* (NAVSHIPS 0967-LP-000-0120) is intended to fulfill the need for an informative reference which describes basic vacuum tube and semiconductor circuits employed in all types of electronic equipment, and provides supporting information for electronic equipment technical manuals.

The handbook includes basic electron tube circuits and semiconductor equivalent circuits

The handbook is sectionalized into general circuit categories, such as power supplies, voltage regulators, amplifiers, and so forth, and is further subdivided into specific circuits. For each electronic circuit described which employs an electron tube or semiconductor, the description is divided into four main parts: application, characteristics, circuit analysis, and failure analysis.

The *Test Methods and Practices Handbook* (NAVSHIPS 0967-LP-000-0130) deals with the use and application of test equipment in installing and maintaining all types of electronic equipment. The handbook provides maintenance personnel with reference information on the fundamentals of test methods and basic measurements, step-by-step procedures for testing typical electronic equipments and circuits, and functional descriptions of the theory of operation of the test equipment used and the circuits tested.

The *Reference Data Handbook* (NAVSHIPS 0967-LP-000-0140) contains encyclopedic arrangement of useful and informative references of pertinent definitions, abbreviations, formulas, and other general data related to electronic installations and maintenance. It is categorically arranged and presented in such a manner as to provide quick comprehensive references.

The handbook contains data such as color and identification codes, parts identification referencing, quantities of units, emission and propagation characteristics, power requirements and distribution systems, and commonly-used electronic formulas.

The *EMI Reduction Handbook* (NAVSHIPS 0967-LP-000-0150) furnishes electronics personnel with approved techniques and procedures for eliminating or reducing electromagnetic interference created by own-forces electromagnetic radiating devices. This book is intended for electronics personnel involved in the installation and maintenance of electronic and electrical systems and equipment.

The *General Maintenance Handbook* (NAVSHIPS 0967-LP-000-0160) discusses the maintenance concepts, techniques, and procedures which are common to all electronic and electrical equipment. Also discussed are preventive maintenance programs, equipment-level and system-level maintenance philosophies, and maintenance of subsystems and repair parts.

Equipment-Oriented Handbooks

The six remaining handbooks in the EIMB series pertain to equipment in the following categories:

- Communications
- Radar
- Sonar
- Test Equipment
- Radiac
- Countermeasures

Each of these handbooks contain general servicing information for the basic equipment category, servicing information for specific equipments, a field change identification guide, and functional descriptions of circuits which are common to the equipment of the basic equipment category.

ELECTRONICS INFORMATION BULLETIN

The Electronics Information Bulletin (EIB), NAVSHIPS 0967-LP-001-3XXX ("XXX" being the EIB number), is an authoritative publication that is published biweekly, and forwarded to all naval ships and naval electronic installation and maintenance activities. It contains advance information of field changes, installation techniques, maintenance hints, safety notices, beneficial suggestions adopted by various yards and bases, and notification of the availability of changes and revisions to technical manuals and the EIMB. All articles, including those under the cognizance of NAVELECSYSCOM, have been authenticated and are authoritative in nature.

As issues are received, they should be filed in a folder or notebook in consecutive order after routing and changes are completed. All EIB

issues must be retained until cancelled. A statement, located on the front cover of each EIB, tells what EIBs have been cancelled.

NAVAL SHIPS TECHNICAL MANUAL

The Naval Ships Technical Manual, Chapter 400 titled "Electronics", provides a list of reference sources available that pertains to electronic equipment and the handling of electronic work.

MISCELLANEOUS PUBLICATIONS OF INTEREST

There are a variety of electronic-oriented publications, some of which will be discussed in the following paragraphs, which are available for guidance in the maintenance of electronic equipment and for reference and study by electronics personnel. Most of these are required publications for your maintenance reference library.

- Shipboard Antenna Systems, is a NAVSHIPS publication consisting of five volumes (or chapters) which serves as a source of information for those concerned with the installation and maintenance of shipboard antennas. Information contained in this manual supplements, but does not supersede, existing specifications. Although this publication is intended primarily for shipboard use, it contains reference information and helpful maintenance hints which may be useful to shore maintenance personnel.

- Single Sideband Communications, NAVSHIPS 0967-LP-307-7010, is a handbook that highlights the important concepts of single sideband (SSB) communications. The handbook identifies and clarifies areas where operators have had difficulty in developing a clear understanding of SSB. It is recommended reading for all personnel associated with operating or maintaining SSB equipment.

- Electronic Administration and Supply, NAVPERS 10835-C, is a training publication promulgated to acquaint naval officers with the with which they should be familiar when assigned to billets concerning electronic material. This book describes organizations, procedures, and facilities for supplying naval electronic materials. It should be required reading material for all personnel involved in, or training for, positions of maintenance administration.

- WECO Monthly Engineering Report is a monthly report published by Western Electric Company under contract from NAVELECSYSCOM Project CAESAR Office. It lists corrective maintenance and equipment problems reported for that particular month by all NAVFACs. The report is divided into two major sections. One section discusses unusual items concerning equipment problems, solutions, comments, and modification information which may be of interest to other commands. The second section lists repair parts used for equipment maintenance. The information for the report is derived from WECO resident engineering technical letters and from the failure report forms that are filled out by maintenance personnel.

- Microelectronic Maintenance Manual, NAVSHIPS 0967-LP-311-5010, is a manual that provides maintenance technicians with information and procedures for performing maintenance on electronic equipments which contain microelectronic circuitry. This book discusses the history, present trends, and future developments in the field of microelectronics, basic processes used in the manufacture of microelectronic devices, and detailed removal and replacement procedures for many types of integrated circuits. This publication should be read by all personnel involved in microelectronic maintenance.

- Index of ESO Program Supported Equipments, Publication No. 9, is an index published by the Navy Electronics Supply Office which provides a listing of Allowance Parts Lists (APLs) in two sections. Section I lists ESO-supported equipment in nomenclature sequence, and includes the APL number, APL date, and the Allowance Support Code. Section II lists

maintenance shop involved in reporting equipments for allowance lists, or for obtaining individual APLs.

- Manufacturer Designating Symbols for Navy Type Numbers and Name Plates for Electronic Equipment, NAVSHIPS 0967-LP-190-4010, is a publication which lists in a convenient format the Navy designating symbols and corresponding Federal Supply Codes (FSC) for commercial firms and government activities which manufacture, or have manufactured, electronic equipment for the Department of the Navy. The designating symbols listed serve to identify the names of manufacturers of Government activities as used in connection with equipment nameplates, parts markings, equipment tabulations, and technical documentation.

UPKEEP OF PUBLICATIONS

Technical manuals, field change bulletins, and other electronics-related publications and periodicals frequently contain typographical, printing, and technical errors which should be corrected. In addition, these documents may require periodic updating to reflect current modifications of equipment or to improve maintenance philosophies and practices. To correct these errors and allow for updating, temporary (interim) corrections, permanent changes, and supplements are published.

Temporary corrections, also called interim changes, contain instructions for making pen-and-ink corrections and changes to publications. In this manner, required information can be promulgated quickly to the users; when printed in the EIB as a publications change, it will reach all activities within a few days after publication.

Permanent changes consist mostly of substitution (or change) pages or section to a publication, but they may also contain pen-and-ink corrections. Usually, the substitution pages and sections contain the corrected information previously promulgated as pen-and-ink corrections and, therefore, supersede them. Permanent changes are periodically listed in EIB issues as "availability items" which can be requisitioned.

Supplemental manuals, also called complementary manuals, are used to augment basic manuals so that both manuals, jointly, contain complete information covering the subject. For technical manuals, the supplemental manuals augment the basic technical manual so that both manuals represent the complete configuration of an equipment and provide all of the necessary information for the installation, operation, maintenance, and repair of the equipment.

Examples of complimentary technical manuals frequently used by maintenance OTs are Digital Spectrum Analyzing Equipment Technical Manual series NAVSHIPS 0967-LP-174-5010 through 5050, and the Vernier Spectrum Analyzing Equipment Technical Manual series NAVSHIPS 0967-LP-036-9010 through 9030. They are used to complement technical manuals for the three types of sonar sets, AN/FQQ-1A(V), 2A(V), and 9(V). Together, they cover a complete sonar set.

Publication revisions are second or subsequent editions of manuals which supersede their preceding editions. They are required whenever current manuals do not accurately or adequately describe the equipment (because of errors, production changes, or when field changes are made to the equipment), and when the extent of permanent change pages would exceed 25 percent of the manual. Revised manuals normally retain the same ordering and stock number as the superseded edition. However, the revised edition will have a later date which is used to identify the current edition.

Maintaining Reference Publications

It is essential that electronic-oriented publications and reference materials be as current and as accurate as possible. Therefore, all applicable publication changes and corrections should be entered as soon as they become available.

Most maintenance divisions assign one person as a publications custodian, making that person responsible for the upkeep of all publications in the reference library. Although the custodian is assigned the responsibility for entering each change or correction, the custodian

may delegate this task to other personnel in the division. However, the custodian should review the publications for accuracy after the corrections and changes have been entered. Instructions for inserting publications corrections and changes are promulgated with the change.

Primarily, the publications custodian is tasked with maintaining an up-to-date reference library. This involves knowing what publications are in the library, where they are stowed, and the change status of each publication. Periodically, the custodian must inventory all publications, update those requiring changes and corrections, and replace or repair those in poor physical condition.

All NAVSHIPS and NAVELEX electronics publications procured in bulk are stocked in the Navy Supply as Cognizance Symbol "I" printed material and are under the inventory control of the Naval Supply Depot, Philadelphia, Pa. NAVSANDA publication 2002, Requisitioning Guide and Index of Forms and Publications Cognizance Symbol "I", includes lists of forms and publications that have been received and are stocked in the system, provides detailed information on how to requisition items, indicates where each item is stocked, and indicates specific limitations on issue. Information is also included on how to identify and obtain non-cognizance "I" forms and publications. NAVSUP 2002 is issued quarterly on micro-fiche cards to all ships and stations. No hard copies are available. Requests for technical manuals in excess of two per equipment will not be approved unless the requesting activity is scheduled to install the equipment in the near future or submits adequate justification.

Before publications can be accurately inventoried, the custodian or person making the inventory must be able to determine what changes and corrections have been entered in each publication. Most publications have a "Record of Corrections" page which is located in the front of the book. If a publication does not have a record of corrections page, one should be made. Examples of record of correction pages can be found in the front of the EIMBs. The record of corrections page should contain information regarding the change number, date of change, the NAVSHIPS or NSN of the change, the date the change was entered, and the name of the person who entered the change. (See figure 1).

For identification, each publication should be assigned a copy number, because usually more than one copy of a publication is held. The copy number should be placed on the record of corrections page and also on the front cover. For flexibility, it is suggested that the copy number be recorded as CY-1, CY-2 and so forth, instead of CY-1 of 2 and CY-2 of 2. This will allow additions and deletions to the library without causing inventory problems.

For ease of access and accountability, most maintenance divisions use a numerical filing system for indexing publications in their reference library. Each publication is assigned a number which can be viewed when the book is stowed on a shelf. Duplicate copies assume the same filing number. On the front of the reference, or in some other convenient location, is a numerical index to the publications contained in the library. Using this method, the user needs only to locate the index number and then look for that particular number on the shelves.

The following method, which is flexible and works well, is suggested for inventorying and updating publications. This method consists of a simple card index file, preferably 5- by 8-inch cards, which contain information regarding inventory record, updating, changes and corrections applicable and entered, classification of the publication, and, if applicable, the classified material control number. (See figure 2.)

In using the card index method, as information is obtained concerning a change which is applicable and not entered, the change number, date of change, and NAVSHIP/NSN numbers should be entered on the card, and the date of entry left blank. Next, information concerning the ordering of the change should be penciled lightly in the margin adjacent to the change number. Before the card is returned to the files, a paper clip should be attached to the top of the card, thus, marking and identifying all cards having changes outstanding.

STATION DRAWING RECORDS

Technical manuals provide many of the drawings you will need for performing

Basic Pub.	02-01-67	NS-0967-174-5020	N.A.	———
Change 1	08-23-67	NS-0967-174-5021	02-24-69	B. Andrews
HT-473-69	08-22-69	HT-473-69, T-00.6	03-05-70	L. L. Brown
Change 2	06-17-68	NS-0967-174-5022	06-15-70	G. Williamson
Change 3	03-24-70	NS-0967-174-5023	07-06-70	K. Gross
Change 4	10-15-70	NS-0967-174-5024	06-30-71	W. A. Stead
MER Dec. 72	12-XX-72	WECO MER December 1972	04-17-73	C. Warden

UNCLASSIFIED

249.10

Figure 1.—Record of Correction Page.

maintenance on sonar and communications equipments at a NAVFAC. These drawings are limited to information on the equipment, primarily at the unit level and lower levels, and do not provide interconnecting information between units of the system. Because different equipment configurations exist within the same type of system, each NAVFAC must have special drawings which apply to their installations. These drawings are called station drawings.

Station drawings serve a number of purposes: they are used by the manufacturer (Western Electric Company) for system design, installation design, station installation, and testing; they serve as a record of "as-built" system; and they provide information for station personnel after the installation.

Station drawings consists of two general groups of drawings: station drawings which apply only to one station, and general drawings which may apply to two or more stations. Both groups carry a six or seven digit designator number which is prefixed by the letter "T" and are commonly referred to as T-drawings. All T-drawings are essentially alike in the following respects: each drawing shows one or more units, the external wiring of the units, and the destination and function of the wiring for these units.

Station T-drawings have a three digit number following the "T" prefix to identify the station. For the older stations, the first number is always the digit "1". This is followed by the two digit station designation number. For example, T-drawings for station 17W would be designated T-117-000 series. Newer stations having the 100-series "W" designators, such as stations 102W and 104W, use T-drawings having the number "2" as the first digit. Station 102W would, therefore, have drawings in the T-202-000 series.

Change #	Date	Identifying Info.	Date Entered	Entered By	Rqn. Info.
Basic Pub	02-01-67	NS-0967-174-5020			
Chg 1	08-23-67	NS-0967-174-5021	02-24-69	Andrews	
HT-473-69	08-22-69	HT-473-69, T-00.6	03-05-70	L. L. Brown	
Chg 2	06-17-68	NS-0967-174-5022	06-15-70	Williamson	
Chg 3	03-24-70	NS-0967-174-5023	07-06-70	Gross	
Chg 4	10-15-70	NS-0967-174-5024	06-30-71	Stead	
12/72 MER	12-XX-72	WECO Dec 72 MER	04-17-73	Warden	

FRONT

INVENTORY RECORD			"I" COG UPDATE		
DATE	BY	CONDITION	DATE	BY	CHANGES REQUIRED

BACK

249.11

Figure 2.—Example of Publications Inventory Control Card, Front and Back views.

General-use drawings applicable to one or more stations are designated by the prefix T-150. Presently, T-150 series drawings are not prepared for the newer stations. Instead, they are issued as station drawings. Likewise, as changes are made to older stations which alter connections between cabinets and units, T-150 series general-use drawings are replaced by station drawings.

The first drawing in the station drawing series is the Station Drawing Record and is designated T-1XX-000 or, if applicable,

all station drawings for that station and serves as an index for locating station drawings. Other drawings in the Station Drawing series are designated as follows:

T-1XX-005, Equipment Generation Breakdown. A listing of all installed equipments by cabinet, stating quantity installed on each cabinet and listing the applicable schematic, wiring diagram, assembly, and lists of material drawing numbers for each unit.

T-1XX-010, Floor Plan for Terminal Equipment Building. A diagram showing the physical layout of the Terminal Equipment Building and location of all equipment cabinets and communications systems.

T-1XX-200, Cable Running List. An index drawing to the T-1XX-200 series station drawings. The 200 series station drawings are Interconnecting Wiring Diagrams (IWD) which provide as-installed wiring information for interconnecting wiring between various units.

T-1XX-500 through 723, Station Power Wiring Lists. Drawings related to power generating and distributing equipment which include fuse and circuit breaker assignments as well as other documentation relative to the power distribution system.

T-1XX-11XX Building items.

T-1XX-15XX Cable laying items (Sea Cable)

T-1XX-3700 Communications items related to Transmitter Building

T-1XX-4500 Communications items related to Terminal Equipment Building.

T-1XX-9001 IWD for Recorder. Reproducer Patching Group (GS-19640 equipment)

The above listed drawings are only a few of the many drawings in the station drawing series. They illustrate the manner in which station drawings are organized. If possible, ask someone in your maintenance division to show you station because it is the key for locating other drawings.

There are several types of station drawings that may be common to one particular unit. Suffix letters, added to the basic drawing number series, identify what type of drawing it is and permit the user to quickly locate all related drawings. Typical suffixes are as follows:

- A Assembly Drawing
- B Cross-Connections
- C Cross-Connections
- D Designation, Circuit
- H Harness, Wiring
- L List of Material
- M Material, Wiring Diagram
- N A temporary drawing showing equipment before and after changes are made.
- R Removal Drawings
- T Terminations, Wiring
- W Wiring Diagram
- X Experimental

General-use T-drawings in the T-150 series are often available after an equipment installation or major revision and may be retained for reference use by the command. In this series, drawing T-150-000 is an index of all general drawings originally issued. It lists all drawings associated with the manufacture and installation of certain common equipment. An example of a T-150 series drawing would be drawing T-150-403 "Antenna, Sleeve" which provides information about sleeve antennas T-150-403-L1 through L8.

Drawings in the T-150 series are divided into the following drawing groups:

1. General-Use Drawings. T-150-001 through 499 and T-150-700 through 899.
2. Sonar Field Test Specifications. T-150-500 through 549, 600 through 649, 900 through 999, and T-151-001 through 500.
3. Communication Field Test Specifications. T-150-550 through 599, 650 through 699, and T-151-501 through 999.
4. Interconnecting Wiring Diagrams, General Use. T-150-0001 through 9999, and 00001 through 99999.

5. General Use, Electrical. T-152-001 through 999.

6. General Use, Mechanical. T-155-001 through 999.

In addition to the general-use T-150 series drawings, there are a number of manufacturing and procurement drawings which use the T-drawing numbers. Examples of a few of these are:

T-250-XXX series—Assembly Drawings.

T-251-XXX series—General-Use Drawings which provide such information as stencil marking of equipment.

T-252-XXX series—Piece Part Drawings.

Normally, any major piece of apparatus or equipment designed for a military project will have the following technical drawings associated with it:

GS	Specification Drawings
GI	Drawing Index
G	Assembly Drawings
LMG	List of Materials (for Assembly Drawings)
G	Schematic Diagrams
G	Wiring Diagrams
G	Test Specifications
G	Apparatus List for Schematic Diagrams (used sometimes with older apparatus).

Many of the technical drawings described above may be found in the equipment technical manuals. However, many are issued separately because of various modifications and field changes that may not be applicable to similar stations.

DRAWING MAINTENANCE

Normally, two sets of drawings are furnished to the command after an equipment installation or modification. Likewise, two sets of drawings are furnished with field engineering modification change kits. Both copies become Navy property along with the equipment and technical resident engineer and the other by the maintenance division.

During an equipment installation or major modification by the contractor, the following sequence of events occurs:

1. The installer (Western Electric Company) corrects or marks two copies of the drawings to reflect the "as-built" condition.
2. Two copies of all unmarked drawings are turned over to the command.
3. One copy of all marked drawings is turned over to the resident engineer for interim use by station personnel.
4. The second marked copy is returned to the contractor for drafting changes.
5. After completing the drafting changes, the contractor furnishes two corrected copies of each drawing to the command.
6. The interim drawings are disposed of and replaced by the new corrected drawings.

After the original equipment installation or after a major equipment modification by Western Electric Company, station drawings must be corrected on-station to reflect subsequent station equipment changes made by station personnel, official Navy Field Changes, contractors, NESC, and so forth.

Note: All proposed and implemented changes which affect the communications and processing equipments at a NAVFAC must be coordinated with NESC through Navy channels.

Drawings that are corrected on station should be corrected as follows:

Deletions—Connections or items to be removed from the drawing should be marked-out with a yellow pencil. This allows subsequent users of the drawing to see the deleted material.

Additions—Connections or items to be added should be marked-in with a red pencil.

Notes—All pertinent notes describing the reason for the change, the authorization, and the applicable dates should be recorded in the "Record of Change" area of the drawing. (Normally this is located in the upper right-hand por-

In making local corrections to station drawings, both copies should be corrected. Usually, when an equipment change or modification occurs, a number of related drawings will also require corrections. By spending a few minutes researching your Station Drawing Record (T-1XX-000) and the Generation Breakdown (T-1XX-005) drawings, you can quickly locate all drawings associated with the equipment change.

When drawings approach the point where revisions should be made, a request should be made to NESC to have them revised. A parallel path is also available through the resident engineer to his organizational line for keeping Western Electric Company informed of all changes. This line, however, does not ensure that revised drawings will be obtained because drawing revisions cost money and must be funded.

Drawing Stowage and Accountability

A typical NAVFAC may possibly maintain several hundred or more station and technical drawings in its files. If the drawings are stored, handled, and used correctly, they will last for many years. If not, they will last only a short time. Maintaining a good set of drawings requires the combined efforts of all personnel who use them. If the drawings are organized and filed properly, the user is more likely to take better care of the drawings and return them to the proper place in the file than if the drawing files are unorganized. A good filing system creates incentive for better use by the users.

One method that is both flexible and effective for maintaining drawings is discussed in the following paragraphs. This method involves an indexing system that is adaptable to continuous updating. It is a filing system that provides physical protection for the drawings and a quick way of locating the desired drawing without looking at a number of additional drawings near it.

revision date, and the "title" as listed on the drawing. An example of a typical drawing record index card is illustrated in figure 3.

After the initial card index file is set up, maintenance from that point on is relatively simple. When a new drawing is received, a new card is added to the file. When a drawing is no longer required, the appropriate file card is removed. As drawing revisions are received, the new information is added to the card and the old information marked out.

Normally, two or more legal size, five-drawer filing cabinets are used for storing drawings. Each drawer will accommodate about a hundred drawings, filed vertically on edge. This method leaves something to be desired because the drawings have a tendency to slide down at the back of the drawer unless they are tightly compressed by the movable bracket in the drawer. This problem can be overcome by adding two permanent drawer dividers to each drawer. The dividers can be locally fabricated from a material such as 1/4-inch plywood or thin gauged metal with a height of about 7 to 8 inches.

With very few exceptions, most drawings, when trimmed and folded properly can be filed in a legal size file folder. For better protection, folders should be of a heavy grade material and have a reinforced top. The "Kraft 1/3rd cut" file folder is suitable for this type of use. For neatness and easy access, each folder should have a label affixed to the top stating the

T-202-010

Floor Plan for Terminal Equipment Building
Station 102W.

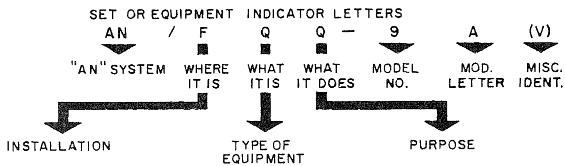
~~Rev. C 09-16-72~~

Rev. D 04-20-73

THAT THE ARMY, NAVY, AND AIR FORCE USE THE EQUIPMENT, BUT MEANS THAT THE TYPE NUMBER WAS ASSIGNED IN THE *AN* SYSTEM.

AN NOMENCLATURE IS ASSIGNED TO COMPLETE SETS OF EQUIPMENT AND MAJOR COMPONENTS OF MILITARY DESIGN; GROUPS OF ARTICLES OF EITHER COMMERCIAL OR MILITARY DESIGN WHICH ARE GROUPED FOR MILITARY PURPOSES; MAJOR ARTICLES OF MILITARY DESIGN WHICH ARE NOT PART OF OR USED WITH A SET; AND COMMERCIAL ARTICLES WHEN NOMENCLATURE WILL NOT FACILITATE MILITARY IDENTIFICATION AND/OR PROCEDURES.

AN NOMENCLATURE IS NOT ASSIGNED TO ARTICLES CATALOGED COMMERCIALLY EXCEPT AS STATED ABOVE; MINOR COMPONENTS OF MILITARY DESIGN FOR WHICH OTHER ADEQUATE MEANS OF IDENTIFICATION ARE AVAILABLE; SMALL PARTS SUCH AS CAPACITORS AND RESISTORS; AND ARTICLES HAVING OTHER ADEQUATE IDENTIFICATION IN JOINT MILITARY SPECIFICATIONS. NOMENCLATURE ASSIGNMENTS REMAIN UNCHANGED REGARDLESS OF LATER CHANGES IN INSTALLATION AND/OR APPLICATION.



A -- AIRBORNE (INSTALLED AND OPERATED IN AIRCRAFT).
B -- UNDERWATER MOBILE, SUBMARINE.
C -- AIR TRANSPORTABLE (INACTIVATED, DO NOT USE).
D -- PILOTLESS CARRIER.
F -- FIXED.
G -- GROUND, GENERAL GROUND USE (INCLUDES TWO OR MORE GROUND-TYPE INSTALLATIONS).
K -- AMPHIBIOUS.
M -- GROUND, MOBILE (INSTALLED AS OPERATING UNIT IN A VEHICLE WHICH HAS NO FUNCTION OTHER THAN TRANSPORTING THE EQUIPMENT).
P -- PACK OR PORTABLE (ANIMAL OR MAN).
S -- WATER SURFACE CRAFT.
T -- GROUND, TRANSPORTABLE.
U -- GENERAL UTILITY (INCLUDES TWO OR MORE GENERAL INSTALLATION CLASSES, AIRBORNE, SHIPBOARD, AND GROUND).
V -- GROUND, VEHICULAR (INSTALLED IN VEHICLE DESIGNED FOR FUNCTIONS OTHER THAN CARRYING ELECTRONIC EQUIPMENT, ETC., SUCH AS TANKS).
W -- WATER SURFACE AND UNDERWATER.

A -- INVISIBLE LIGHT, HEAT RADIATION.
B -- PIGEON.
C -- CARRIER.
D -- RADIAC.
E -- NUPAC.
F -- PHOTOGRAPHIC.[1]
G -- TELEGRAPH OR TELETYPE.
I -- INTERPHONE AND PUBLIC ADDRESS.
J -- ELECTROMECHANICAL OR INERTIAL WIRE COVERED.
K -- TELEMETERING.
L -- COUNTERMEASURES.
M -- METEOROLOGICAL.
N -- SOUND IN AIR.
P -- RADAR.
Q -- SONAR AND UNDERWATER SOUND.
R -- RADIO
S -- SPECIAL TYPES, MAGNETIC, ETC., OR COMBINATIONS OF TYPES.
T -- TELEPHONE (WIRE).
V -- VISUAL AND VISIBLE LIGHT.
W -- ARMAMENT (PECULIAR TO ARMAMENT, NOT OTHERWISE COVERED).
X -- FACSIMILE OR TELEVISION.
Y -- DATA PROCESSING.

A -- AUXILIARY ASSEMBLIES (NOT COMPLETE OPERATING SETS USED WITH OR PART OF TWO OR MORE SETS OR SETS SERIES).
B -- BOMBING.
C -- COMMUNICATIONS (RECEIVING AND TRANSMITTING).
D -- DIRECTION FINDER, RECONNAISSANCE, AND/OR SURVEILLANCE.
E -- EJECTION AND/OR RELEASE.
G -- FIRE-CONTROL OR SEARCHLIGHT DIRECTING.
H -- RECORDING AND/OR REPRODUCING (GRAPHIC METEOROLOGICAL AND SOUND).
K -- COMPUTING.
L -- SEARCHLIGHT CONTROL (INACTIVATED, USE G).
M -- MAINTENANCE AND TEST ASSEMBLIES (INCLUDING TOOLS).
N -- NAVIGATIONAL AIDS (INCLUDING ALTIMETERS, BEACONS, COMPASSES, RACONS, DEPTH SOUNDING, APPROACH, AND LANDING).
P -- REPRODUCING (INACTIVATED, DO NOT USE).
Q -- SPECIAL, OR COMBINATION OF PURPOSES.
R -- RECEIVING, PASSIVE DETECTING.
S -- DETECTING AND/OR RANGE AND BEARING, SEARCH.
T -- TRANSMITTING.
W -- AUTOMATIC FLIGHT OR REMOTE CONTROL.
X -- IDENTIFICATION AND RECOGNITION.

[1] NOT FOR US USE EXCEPT FOR ASSIGNING SUFFIX LETTERS TO PREVIOUSLY NOMENCLATURED ITEMS.

20.484

Figure 4.—AN system.

drawing number. An ideal label for use in this application is Automatic Business Machine (ADP) 3 1/2- by 15/16-inch rectangular self-adhesive label.

When a drawing is needed from the drawing files, the drawing should be removed from the folder and the folder retained in the drawer. When drawings are removed from the files for extended periods, a note should be placed in the folder or on the drawing index card stating where the drawing is. This provides a method of accountability and also informs another would-be user as to where the drawing is located.

GENERAL MAINTENANCE

One of the first things a maintenance technician must learn is how to identify various electronic equipments, sub-units, and components by the appropriate nomenclatures. In many cases you may find several methods of identifying a particular equipment and this may be somewhat confusing. For example, the proper nomenclature for a Tektronix 541A (colloquial name) oscilloscope is an AN/USM-64 Oscilloscope. This scope can be also identified as a CBTV-541A, or by Western Electric Co. part number G-330503, or it can be referenced by a unit location number, such as Unit 406A5. Each of the preceding designations provides useful information to the maintenance technician as well as to others who may be concerned with the equipment.

JOINT ELECTRONICS TYPE DESIGNATION SYSTEM

The Joint Electronics Type Designation System, commonly called the "AN System", is jointly used by the Army, Navy, and Air Force to identify equipments by a system of standardized nomenclatures. The AN nomenclature consists of an approved name and a type number. For example, Sonar Set AN/FQQ-9A(V).

The AN nomenclature for a complete set, such as in the above example, will consist of three indicator letters and an assigned number. The three letters tell you where it is, what it is, and what it does. See figure 4 for the codes used for example, you can see that it is a fixed-sonar system of special or combined purposes, model number 9, and modified. The (V) signifies the equipment is of variable configuration.

On experimental models or models prior to production, a two-letter indicator followed by an identifying number may be assigned. The first letter identifies the equipment as preconstruction, the second letter designates the developing activity, and the figure identifies successive versions. An example of this is Sonar Set AN/FQQ-9(XN-2).

In addition to complete set nomenclatures, major components are also designated by the AN system. However, the nomenclature is different. Components are assigned a one- or two-letter component indicator and a number or group of numbers. When the component is part of a set, a slant sign is used and the parent equipment nomenclature added. For example, the Sequential Timer TD-494/FQA-4(V) is assigned the letters TD which identify the unit as a timing device. Note that the parent equipment (AN/FQA-4(V)) designation has the AN prefix dropped.

Other common component indicators which you will be using and should be familiar with are listed in table 1. Additional information on the AN system can be found in EIMB reference book NS-0967-LP-000-0140.

SYSTEM CODING

To aid in identifying equipment parts, the Navy employs a standard method of coding each major equipment unit, subunit, and component of each equipment system. Under the coding system, each maintenance part is assigned a reference designation number called a reference symbol or a circuit symbol. The reference designations are the same as the ones found on schematics, wiring diagrams, and parts listing in the equipment technical manuals. The reference designation indicates the major equipment unit, sub-unit or units, and the actual part. See figure 5.

The first part of the reference designation gives the unit location number. Next, the highest subassembly designation is given. If the part is located in a subassembly of the highest sub-

Table 1.—AN System Component Indicators

ent tors	Family Name	Examples of Use (Not To Be Construed as Limiting the Application of the Component Indicator)
	Amplifiers	Power, audio, interphone, radio frequency, video, electronic control, etc.
	Controls	Control box, remote tuning control, etc.
	Loudspeakers	Separately housed loudspeakers, intercommunication station.
	Meters	Multimeters, volt-ohm-milliameters, vacuum tube voltmeters, power meters, etc.
	Miscellaneous	Equipment not otherwise classified, includes subassemblies.
	Oscillators	Master frequency, blocking, multivibrators, etc. (for test oscillators, see SG).
	Operating assemblies	Assembly of operating units not otherwise covered, used with or part of one set or set series.
	Oscilloscope, test	Test oscilloscope for general test purposes.
	Power supplies	Nonrotating machine type such as vibrator pack, rectifier, thermoelectric, etc.
	Power equipments	Rotating power equipment except dynamotors, motor-generators, etc.
	Receivers	Receivers, all types except telephone.
	Recorders	Sound, graphic, tape, wire, film, disc, facsimile, magnetic, mechanical, etc.
	Generators, signal	Test oscillators, noise generators, etc. (see O).
	Transmitters	Transmitters, all types, except telephone.
	Test items	Test and measuring equipment not otherwise included; boresighting and alignment equipment.

1 R 1

unit No. — class of item — item No. within class

A-This example is read as: First (1) resistor (R) of first unit (1).

4 A1 R1

unit No. — subassembly designation — class and No. of item

B-Read as: First (1) resistor (R) of first (1) subassembly (A) of fourth (4) unit.

3 A1 A2 R1

unit No. — subassembly designation — subassembly designation — class and No. of item

C-Read as: First (1) resistor (R) of second (2) subassembly (A) of first (1) subassembly (A) of third (3) unit.

249.43

Figure 5.—System coding.

first. After the unit and subassemnly designation, the part reference symbol or circuit symbol is given. For example, a reference designation of "400A1A2 C7" identifies the part as a capacitor, the seventh in a series, located in subassembly A1A2 of unit 400.

In equipments where special test points or test jacks are included, the associated designation is referenced on the schematic diagram. Items such as terminal boards, terminal strips, tube and relay sockets, or other plug-in devices are referenced by the part designation plus a number which denotes the terminal of the part. For example, the designation XV1-5 represents pin five of tube socket V1.

ELECTRICAL DIAGRAMS

diagrams. The three most frequently used diagrams are block diagrams, wiring diagrams, and schematic diagrams. Each will be discussed in the following paragraphs.

Block Diagrams

A basic block diagram is one in which the essential units of any system are illustrated by interconnected (drawn or implied) rectangles, circles, or descriptive shapes. This type of diagram usually includes the names of each unit and has general characteristics and output/input data flow tagged.

A functional block diagram is used to provide an overall picture of the major units of the system and the signal flow between them. The layout and interpretation of the connecting lines and the representation of blocks depend upon the complexity of the equipment or system. Figure 6, for example, is a typical block diagram of a single sideband transmitter. The lines that connect the various functional blocks simply represent important signal flow connections from one functional unit to another.

Another form that a functional block diagram may take is the internal functional block diagram of one or more units of a system. When the functional block diagram is a unit representation, each block represents a circuit group designed for a specific function. (Again, the lines from the output of one circuit group will be connected to the input of the next.)

Functional diagrams are consulted in the early phases of any trouble-shooting problem to enable the isolation of any unit(s) of the system that may be causing the indicated trouble symptom. Consequently, the more knowledge the operator has regarding the overall analysis, as represented by a functional block diagram, the easier the trouble analysis becomes.

Each equipment technical manual will usually have several block diagrams which will cover the equipment on an overall level,

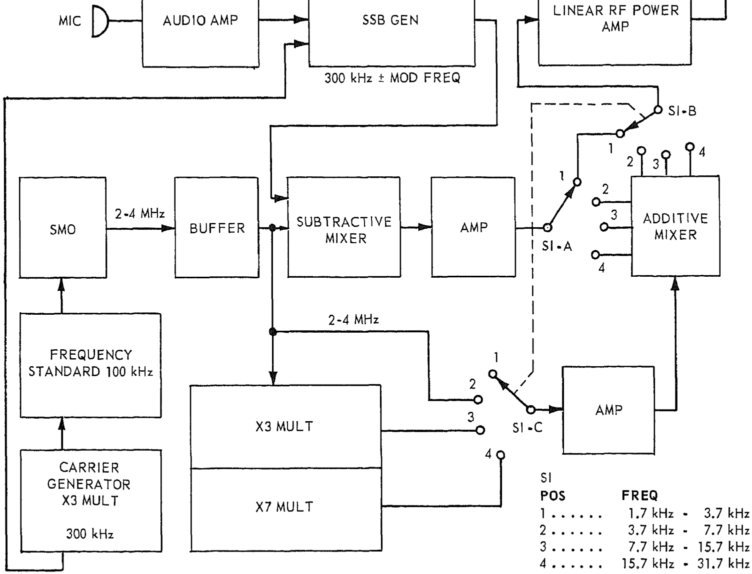


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Figure 6.—Typical functional block diagram showing a single-sideband transmitter.

are provided for troubleshooting and maintenance checks.

Wiring Diagrams

A wiring diagram shows the general outline of the equipment, including the placement of the parts on the various shelves and the actual run of the wires connecting the numerous components. Connections to the pins of the vacuum tubes and other parts, such as capacitors and coils, appear as though you were looking at the equipment itself. Wiring diagrams are useful when parts or wiring must be replaced. Figure 7 shows an example of a typical wiring diagram.

Schematic Diagrams

As the name implies, a schematic diagram shows the scheme of the wiring in a circuit. All electronic parts of the equipment are represented by electronic symbols. Schematic diagrams are drawn to show only the electronic relationships of the circuitry, and the symbols do not show the physical relationships of the parts as in a wiring diagram. Schematic diagrams are very useful in toubleshooting equipment because the electrical relationship between all components is clearly established. Figure 8 shows a typical schematic diagram. NOTE: Figure 8 is the schematic of the wiring diagram shown in figure 7.

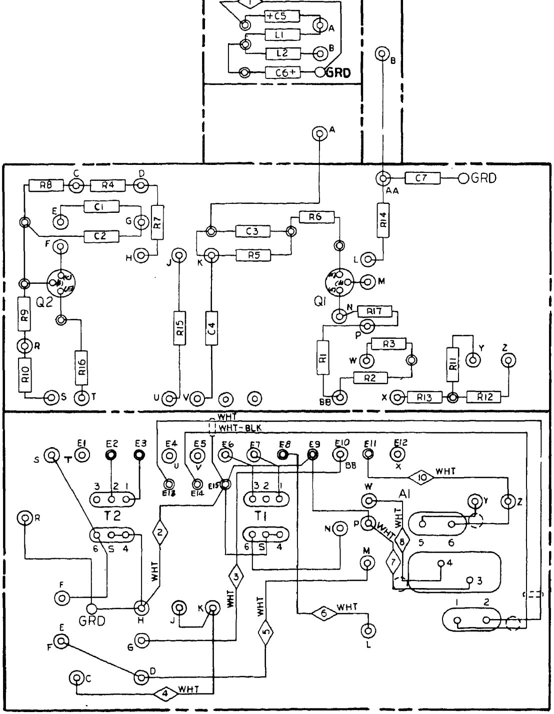

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Figure 7.—Typical wiring diagram.

CORRECTIVE MAINTENANCE PROCEDURES

An OT must be thoroughly familiar with the theory of operation of the equipments he services to be able to recognize trouble symptoms. Knowledge of the theory of operation is acquired through formal schooling and on-the-job training, and is aided by the use of equipment technical manuals.

Skill is also necessary in the use of test equipment and handtools. Skill is acquired with practice and careful study of the instruction book that comes with each piece of test equipment. Often, tests and measurements indicate conditions that may be corrected before an actual breakdown occurs. Thus, tests and measurements (particularly measurements) are important factors in both preventive and corrective maintenance. When a system test reveals that a

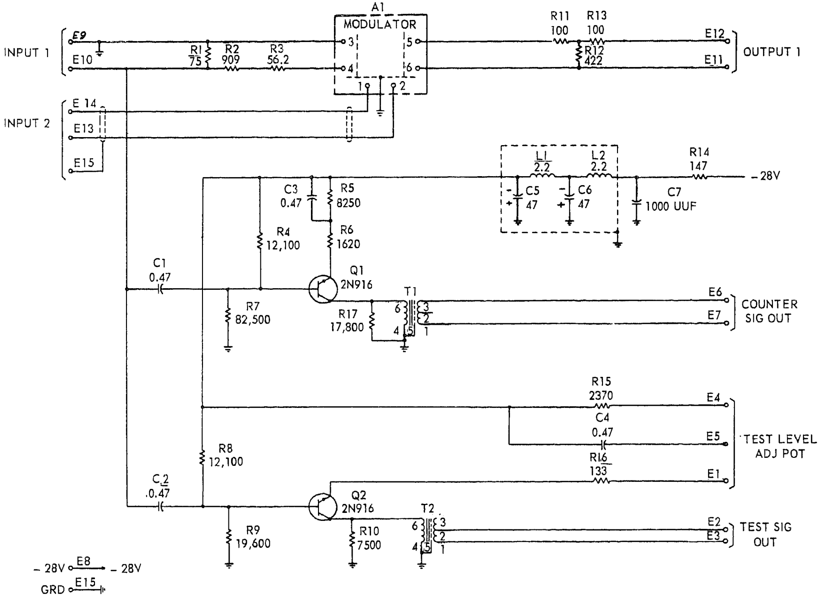

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Figure 8.—Typical schematic diagram.

measurement is not within tolerance, it indicates a defective component that must be isolated.

Depending on the type of equipment, there are numerous ways to isolate a fault. Before the OT can determine that the equipment is not functioning properly, he must first know what each unit does. Second, the best way (and the most economical in time and effort) to isolate a fault is by using a logical troubleshooting method.

Keep in mind that the largest sections of an average technical manual are devoted to corrective maintenance. These sections are written (described later), they can be the most valuable part of the book for you.

Logical troubleshooting is a time-proven procedure used by all accomplished technicians. Most technicians have applied the procedure so often that they no longer pay any attention to its fine points. Through habit and years of experience they may have forgotten its specific details, but the procedure is there and has remained the same.

Probably no two technicians would explain the procedure alike, but each would agree that logical troubleshooting consists of a series of sequential steps, based on valid decisions, that

same. Six steps have been chosen as representative of the easiest method of learning and applying the troubleshooting procedure. In sequential order, the steps are as follows:

1. Symptom recognition
2. Symptom elaboration
3. Listing the probable faulty function
4. Localizing the faulty function
5. Localizing the faulty circuit
6. Failure analysis

SYMPTOM RECOGNITION

The first step in any troubleshooting problem is recognition of a trouble indication. Recognizing a trouble condition in a system is not always easy, because all conditions of less than peak performance are not always apparent.

The existence of a trouble can be detected in many ways. Obvious troubles will undoubtedly be reported by the operator as they affect the display presentation. Usually these conditions include complete or almost complete malfunction of the equipment. Troubles that cause a gradual decrease in equipment performance are not easily noticed and often go undetected until the problem becomes more severe.

Inasmuch as your facility or ship depends on full equipment performance, the hidden trouble symptoms must be found, the cause of the trouble located, and the repair made. If an OT makes a point of looking for trouble symptoms every time he works on the equipment, most of the decreasing performance symptoms will be recognized easily by the difference in the measured values obtained. While troubleshooting, he should look for visual indications of imminent component failure which, if unnoticed, will cause a future breakdown.

SYMPTOM ELABORATION

Breaking out test equipment and schematics and proceeding headlong into troubleshooting on only the initial symptom recognition signs can result in unnecessary work. A zero reading on a panel meter, for example, is insufficient

Analysis of the problem requires the technician to make full use of front panel controls and built-in performance measuring indicators. Additional information can be obtained about any malfunction by making a systematic front panel check. If the technician is reasonably familiar with the principles of the equipment's operation, manipulation of appropriate controls and switches, corresponding checks of equipment meters, and the use of test equipment will reveal to him how the trouble is affecting the entire equipment. From these clues he is able to narrow the probable areas of the equipment that may contain the trouble.

LISTING PROBABLE FAULTY FUNCTION

The third step requires that the troubleshooter make a tentative conclusion concerning the probable cause of the trouble. From the elements of the trouble symptom, as he identifies them, he determines their most logical locations. These locations are confined to major or functional units of an equipment. Conclusions are formed from the knowledge of how the equipment works and a study of the equipment's functional block diagrams.

LOCALIZING FAULTY FUNCTION

In localizing the faulty function, one of the conclusions reached above must be selected for testing. It is not necessarily the one thought of first, nor the one that past experience suggests as being the most attractive. Selection of the functional unit to be tested (or verified) first should be based not only on priority or validity, but also on the difficulty in making the necessary tests. Under some circumstances, a troubleshooter may elect to test the second alternative rather than the first because the latter might entail testing difficulties that should be initially avoided or might require unnecessary tampering with circuit parts. Like all the other steps in the troubleshooting procedure, this step places emphasis on common-sense thinking to localize the faulty function.

check is made at the output test point of the selected unit. The test equipment reading is compared with the desired result indicated in the technical manual. A zero output reading is easy to recognize; however, a distorted or nonstandard output may not be. Questionable readings should be verified carefully before arriving at a technical conclusion.

If the OT does his mental work properly, the manual labor in gaining access to test points and the use of test equipment will be held to a minimum. This procedure is opposed to the trial-and-error method where the technician searches from point-to-point with test prods, hoping to locate the faulty test reading that identifies the trouble.

Upon completing the verification of the probable faulty unit selected, the OT will be able to form one of several conclusions. The test may verify that the trouble is in a certain unit, that the trouble could be in one unit plus one or more other units from which it receives signals or control voltages, that the trouble is not in a specific unit at all, or that the output looks suspicious and requires further verifying tests.

Whatever the conclusion, information that will substantiate or eliminate suspected units or provide evidence for adding another will be acquired? Tests of suspected unit outputs are continued until the single faulty unit is identified. At that point, the trouble has been narrowed to a fraction of the total number of circuits and parts in the equipment. If the proper procedure is carried out at this time, the search can be confined to the functional unit isolated.

LOCALIZING FAULTY CIRCUIT

After isolating the faulty unit, the next step is to isolate the faulty circuit. The same narrowing procedures are used here as before. The unit is mentally subdivided into circuit groups by function, and valid technical reasoning is employed to select the groups that probably will contain the problem. Using this procedure, the technician can find the faulty circuit without going through the unnecessary time-consuming chore of test-point to test-point checking from one end

with the information obtained in the preceding steps to narrow the trouble to a single functional grouping. This process is called "bracketing".

Using the bracketing method, brackets are placed, mentally or in pencil, around the area in which the trouble lies. Initially, a bracket is placed in the input(s) of the units that are known to be good and at the output(s) known to be bad. As each deduction is made and verified by a test, the input or output bracket is moved to the next point in the block diagram where the test was made. In this manner the closing bracket systematically restricts the fault to a single circuit.

Usually the servicing block diagram can serve as the instrument for the complete bracketing process. Sometimes, however, it is necessary to refer to a schematic diagram for bracketing or testing data. Sufficient diagram information is available in the technical manual to support the bracketing procedure and preclude the wastefulness of unreliable circuit-to-circuit testing. This step is completed when the technician isolates the trouble to a single circuit and verifies that the output of this circuit is the cause of the distorted output reading of the unit.

FAILURE ANALYSIS

The troubleshooting procedure thus far has narrowed the trouble to a single circuit consisting of a number of components. These components should then be checked with appropriate test equipment.

When the faulty part is identified, it should not be replaced until the OT can substantiate that it actually is causing the trouble. Replacing the part without adequate technical reason may not cure the problem and it could cause further trouble. Always analyze the failure before making the repair.

It can now be seen that the six-step troubleshooting procedure is designed to isolate a trouble in a timely and orderly manner. Success in using the procedure depends on the OT's knowledge of electronics, the equipment under test, and his skill in using the technical manual and test equipment. The process is no

more complicated than the ability to subdivide the equipment into progressively smaller functional areas, such as functional units into functional circuit groups, to a circuit, and finally to a part or adjustment within a circuit. The procedure described is the only logical method of troubleshooting equipment. It is considered more reliable and also faster than any other method.

After any corrective maintenance is completed, the technician must next realign the equipment worked on before he can consider the equipment as completely operational. The extent of realignment depends on the level on which the corrective maintenance was performed. Realignment should be done in accordance with the technical manual for the individual equipment.

MODULES

It is of the utmost importance that Ocean Systems Technicians keep abreast of the latest equipments in the field as well as the technical skills necessary to maintain them. Most of the newer equipments have some degree of modular construction. The techniques for repairing these modular equipments have brought about a necessity for maintenance technicians to attain skills not previously required of them.

MODULAR CONSTRUCTION

A modular assembly may provide for either a single function or for multiple functions. Two or more modular assemblies may be used to form a portion of a unit that is replaceable as a whole, but which have an individually replaceable part (or parts). These modular assemblies may be expanded to become building blocks in an ultimate tier. To be more specific, modular construction is a type of unitized construction consisting predominantly of modular assemblies. Analog computing systems, which may be enlarged by the addition of packaged units containing amplifiers, function generators, potentiometers, and the like, are examples of modular construction. The primary advantages of modular construction are in the reduction of different

they can be replaced. Modular construction provides for compactness with reliability, and permits interchangeability. Examples A and B in figure 9 illustrate two possible configurations of modular construction. Certain standards must be met to successfully service modular assemblies. Usually, more skill is required for servicing modular assemblies than for repairing wired circuits. Specialized techniques, an adequate complement of tools, and a certain degree of dexterity and patience are requirements for this type of servicing.

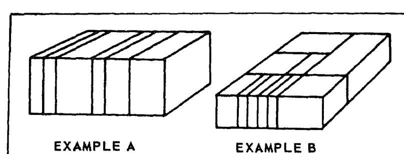
The subminiature construction features of modular assemblies, such as printed circuit boards, transistors, subminiature tubes, and pin assembly circuits (packaged units), make it necessary, in most instances, to use special repair techniques. These repair techniques are discussed in the topics that follow.

TERMS AND DEFINITIONS

In discussing subminiature repair techniques, several terms are used. To give you a better understanding of the subject, the following list of terms and definitions is provided.

Assembly: Several parts (or subassemblies) or any combination of parts joined together to perform a specific function.

Module: A unit or standard of measurement; a fixed dimension; a packaged functional assembly of wired electronic components for use with other such assemblies.



Modular Assembly: An assembly having outlined dimensions which are multiples of a module.

Unitized Construction: A type of unitized construction consisting chiefly of replacement assemblies.

Modular Construction: A type of unitized construction consisting mainly of modular assemblies.

PRECAUTIONS

Considerable experience is required in working with transistors, printed circuits, and modular assemblies. Modular assemblies, although mechanically more rugged than conventional circuits, are comparatively easy to damage by improper handling or electrical overload. Consequently, it is necessary to keep in mind certain general precautions at all times. A few of these precautions are listed below.

Do not overheat transistors, other semiconductors, or any miniature parts. They can be destroyed by excessive heat. If it is necessary to solder or unsolder a semiconductor or other miniature parts, use a clean, well-tinned pencil soldering iron and a good-quality, low-temperature solder. Complete the soldering process as quickly as possible. For maximum protection, hold the lead to be soldered with a pair of longnose pliers or a hemostatic clamp. The pliers or clamp should be held between the point where heat is applied and the body of the semiconductor or miniature part. Used in this manner, these tools form a "heat sink" to conduct heat away from the part itself. (NOTE: Place a small piece of beeswax between the semiconductor and the heat sink. When the wax melts, the temperature limit has been reached. This indication is a warning to remove the source of heat immediately.)

Do not exceed the absolute maximum electrical rating of the modular assembly under test or repair. Maximum electrical ratings are given in the technical manual tables and drawings supplied by the manufacturer for each part under test. In general, transistors, similar components, and associated miniature parts are not under- adherence to the maximum rating specified by the manufacturer and to the steps and procedures given in the technical manual.

SPECIAL TOOLS AND SOLDER

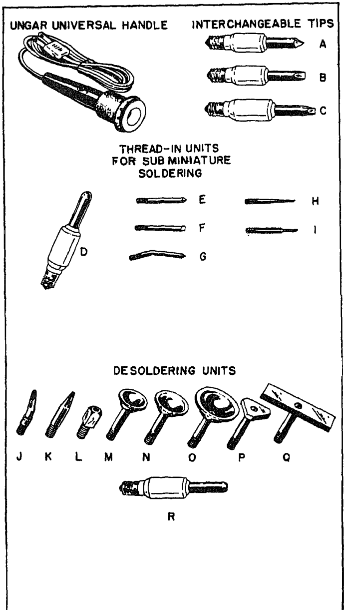
The main causes of part or board damage in modular assembly repair are excessive heat and the use of improper tools and material. Special tools and material are required that ordinarily are not used in servicing the more conventional wired circuit chassis. The main problem is the soldering iron. A light-duty soldering iron (pencil type) of 23 1/2 to 37 1/2 watts should be used. A heavy-duty soldering iron or a soldering gun should never be used.

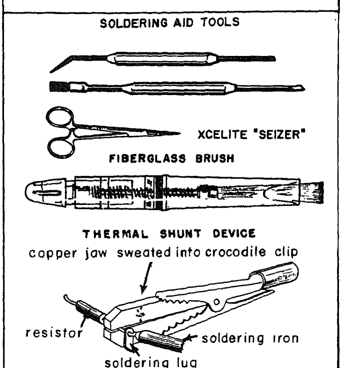
A later discussion explains in detail the techniques and specific procedures for soldering and removing parts. Personnel assigned to repair modular assemblies should be provided with, and use, the recommended tools. Some of these tools are listed on electronic tool allowance lists; others, indicated by an asterisk(*), are procurable through local purchase. Figure 10 illustrates the commercial items.

All other tools used for modular assembly repair are standard handtools and are listed in the electronic tool allowance list. At a naval facility, many of these tools are carried in supply as replacement items for the teletype tool box.

Selection of the proper solder is the next step required for troublefree repair. Always use a small-diameter, rosin-core solder with a tin-to-lead ratio of 60/40 (60% tin, 40% lead). Never use a tin-to-lead ratio of 40/60. Nor should you use a large-diameter solder with a high lead content. Because of the high melting heat required, use of this type of solder will damage the printed circuit board, transistor, or other miniaturized part of the modular assembly.

High-quality solder of small diameter requires less heat to solder a strong and lasting joint. The ideal solder is known as eutectic, a combination of 63% tin and 37% lead, which melts at 360°F. For all practical purposes the 60/40 solder, which melts at 370°F, can be used satisfactorily without damaging the modular components. (NOTE: An exception to this procedure is when soldering a silverplated or solid





Item	Description	Federal or Commercial Stock No.
Soldering Iron—		
	*Ungar Electric Tools Co.	
	Pencil Iron Set	
	Handle assembly	776
	Thread-Units for Sub-miniature soldering	
A	Pyramid tip, 5/16" diameter	1236
B	Chisel tip, 3/8" diameter	1239
C	Chisel tip, 1/4" diameter	1233
D	Thread-in element for thread-in tips	1235
E	Thread-in straight cone tip, 3/8" diameter for element D	PL331
F	Thread-in straight chisel tip, 3/8" diameter for element D	PL332
G	Thread-in bent cone tip, 3/8" diameter for element D	PL333
H	Thread-in straight needle tip, 3/8" diameter for element D	PL338
I	Thread-in micro tip for element D	PL340
Desoldering Units for Subminiature Repair		
J	Thread-in offset slotted tiplet for element R	862
K	Thread-in straight slotted tiplet for element R	857
L	Thread-in hollow cube tiplet for element R	863
M	Thread-in 5/8" diameter cup tiplet for element R	856
N	Thread-in 3/4" diameter cup tiplet for element R	855
O	Thread-in 1" diameter cup tiplet for element R	854
P	Thread-in 5/8" diameter triangle tiplet for element R	861
Q	Thread-in 1-1/2" x 3/8" bar tiplet for element R	858
R	Thread-in element for de-soldering tiplets	4045

cuit.)

CAUTION: Use only a solder with a noncorrosive and nonconductive rosin core. Under no circumstance should an acid-core solder be used because it will cause corrosion, shorts, and leaks. Acid-core solder is used in plumbing, not for electronic repair.

POWER SUPPLY POLARITIES

Observe power supply polarities when measuring the resistance of the circuits of modular assemblies containing transistors or other semiconductors. Such parts are polarity and voltage sensitive. Reversing the plate voltage polarity of a triode vacuum tube will keep the stage from operating, but normally will not damage the tube. Reversing the collector voltage polarity of transistors or other semiconductor devices, however, will ruin them instantly and permanently.

Inasmuch as transistors and similar components require different power supply connections, when you work with these parts always follow the directions given on the applicable tables or drawings to ensure that the correct polarity and ranges are observed. Recheck your work before turning on the power; the wrong polarity will destroy the part.

HIGH TRANSIENT CURRENT OR VOLTAGES

Guard against high transient current or voltages when testing or servicing. A damaging transient pulse may be caused in a number of ways. The following items, listed under "Precautions" represent some of the most frequent causes for accidental transient conditions that should be prevented.

PRECAUTIONS

1. Do not apply a.c. power-operated test equipment or soldering equipment without first making certain that no leakage current is emitted from them. The use of an isolation transformer is a good precaution to follow with all test equipment contains a transformer in its power supply or shows no current leakage. With all test equipment (whether transformer-operated or not), a common ground lead should always be connected first from the ground of the circuit to be tested and then to the test equipment ground.

2. Do not apply too high a pulse from test equipment. The safest procedure is to start all test equipment from zero settings, and then proceed with the test steps as outlined in the equipment technical manual. Be sure that the signal applied is below the rating given for the circuit under test. Relatively high current transients can occur when test equipment is connected to a circuit where low impedance paths exist.

3. Do not loosen connections, disconnect parts, insert or remove transistors or similar components, or change modular assemblies while the equipment power is on or while the circuit is under test. When modular assemblies are changed, be sure that the equipment power is off. A loose connection or any of the actions mentioned above will cause an inductive kickback. This reaction can be prevented by making sure that all parts in the circuit are secure before the test is started or the equipment power is turned on. Be sure to remove all possible capacitive charges from parts and test equipment before they are applied to a modular assembly.

HANDLING AND PACKAGING

Handle modular assemblies carefully at all times. Unnecessary damage has occurred to modular assemblies by thoughtless and careless action in handling and packaging. Proper packaging of modular assemblies will prevent unnecessary damage. Always remember that just because a modular assembly is defective does not mean it is beyond repair.

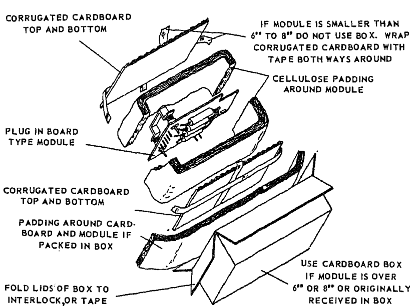
A new assembly is received packaged in accordance with the applicable packaging specification. When the outer bulky casing (crate or outer carton with its shredded paper dunnage or similar material) is removed, the unit or units will remain packed in a watertight package. This package is stored by the issuing activity until drawn by the using activity. Thus,

the using activity receives the proper packaging materials with which the defective module can be packaged for shipment to a repair facility.

Figures 11A, 11B, and 11C show the correct method and proper packing materials that should be used for storing or transferring defective modules until they are received by a shipping facility. NOTE: When repacking a defective module, do not use the desiccant crystals that were originally in the package.

Regardless of the module design, if its pins, shafts, dials, or other protruding parts are fitted adequately with packing spacers, and if the module is wrapped properly with protective cellulose (Kimpak or similar material), the using activity will have done its part in preventing transport damage to the modular assembly.

In the past, unnecessary damage has occurred to modular assemblies because of rough handling. Particular care must be given to the method of removing or inserting a module into the equipment. If the module is a plug-in, board-type assembly, be sure the guide pins are properly aligned before pressing the assembly into place. If the board should tilt while being inserted, do not continue to press it into position; straighten it then apply even pressure to avoid tilting. Forcing a tilted or crooked modular assembly into position may result in bent or broken pins.



70.127

Figure 11A.—Protective packaging of a bolt-down chassis-type module.

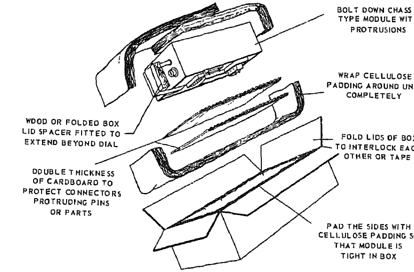


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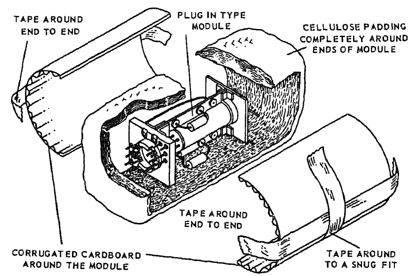
Figure 11B.—Protective packaging of a plug-in board-type module.



70.128

Figure 11C.—Protective packaging of a plug-in type module.

When removing a modular assembly, be sure to pull it straight out from the equipment. Because of the miniaturization of parts for modular construction, leads, connectors, pins, and so forth, have been stiffened to make them more rugged. As a result, such fragile parts are brittle and will break easily if bent too often or if uneven pressure is applied. When handling a module that has been removed from its chassis, be careful not to press against the leads or pins. If a lead or pin is accidentally bent, do not try to straighten it unless absolutely necessary.

When repairing a modular assembly, be careful that the tool employed does not inadvertently press against leads, pins, or other parts that are easily bent. Such pressure can destroy a good part and cause needless repair.

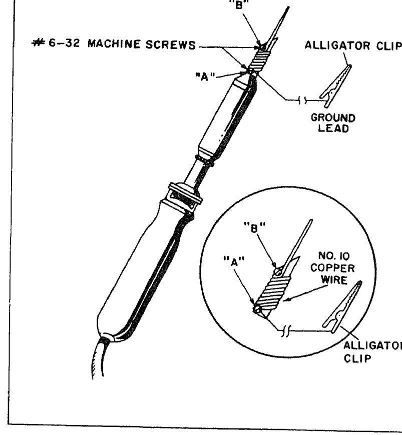
REMOVAL AND REPLACEMENT OF PARTS

Replacement of miniature and subminiature parts found in modular assemblies requires more consideration than is normally given to parts in the servicing of other types of electronic equipment. Before attempting repair, maintenance personnel should become thoroughly familiar with the correct repair and soldering techniques because the servicing procedures differ.

● Soldering set: The compactness of modular assemblies makes it imperative that a small, low-wattage pencil iron be used. The soldering iron should have a small tip so that heat can be applied directly to the terminal of the part to be removed or replaced without overheating the printed circuit board or adjacent parts. The recommended Ungar pencil iron set (mentioned earlier) is designed for this type of work. If a low-wattage iron is not available, a high-wattage iron can be effectively used when converted to a low-heat unit, but it should be used for emergencies only. To make the conversion, closely wrap a number of turns of clean No. 10 copper wire around a thoroughly clean soldering iron tip, extending the other end of the wire about one inch beyond the original soldering iron tip. Thoroughly tin the formed end of the new tip before using it. This improvised instrument will then serve as a low-wattage soldering iron tip. (See figure 12.)

To provide a tight connection and prevent possible twisting of the tip, the No. 10 wire coil ends should be secured at points A and B with No. 6-32 machine screws. The foregoing instructions apply to all subsequent examples of improvised soldering tips.

A flexible ground wire (No. 14) should be attached at point A shown in figure 12. The other end of this wire should be provided with an alligator clip to permit convenient grounding of the soldering iron to the module chassis.



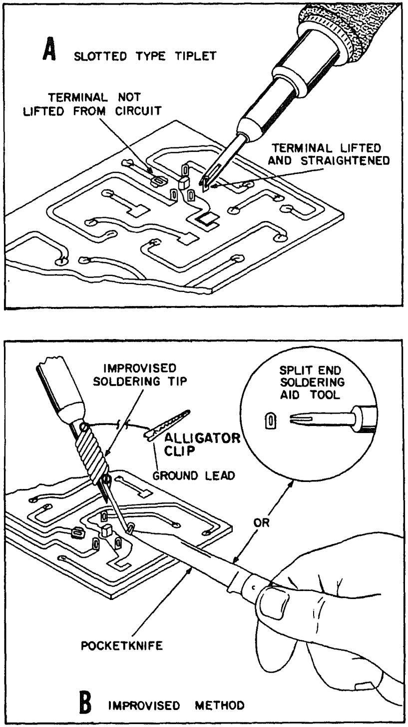
70.123.0

Figure 12.—Improvised soldering tip for modular repair.

CAUTION: If an improvised high-wattage soldering iron is to be used for work on transistors or other transient voltage-sensitive components, a ground lead must be connected from the tip of the soldering iron to the frame or chassis of the module. This precautionary measure is necessary to prevent damage to transistors and other parts from leakage of current in the soldering iron.

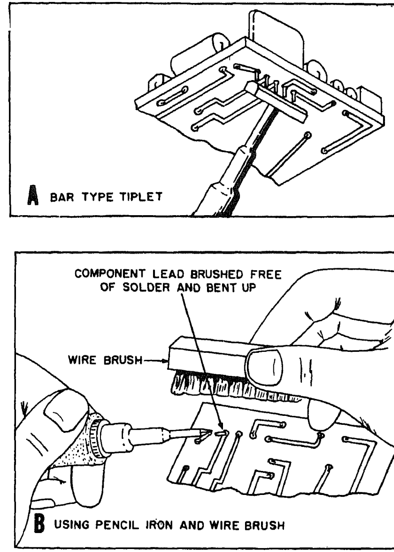
● Desoldering set: A practical soldering iron with tips specially designed for soldering and unsoldering parts from printed circuit boards has been developed by Ungar Electric Tools, Inc. (See figure 10.)

The Ungar offset or straight slotted tiplets (Ungar Nos. 862 and 857) will simultaneously melt the solder and straighten the leads, tabs, and small wires bent against the board or terminal, as illustrated in view A of figure 13. If this tool is not available, the improvised soldering tip shown in figure 12 may be used with a split-end soldering aid tool (General Cement



70.124F,G

Figure 13.—Special soldering iron adaptions-slotted-type tiplet, and improvised methods.



70.124A,B

Figure 14.—Special soldering iron adaptions-bar-type tiplet and wire brush methods.

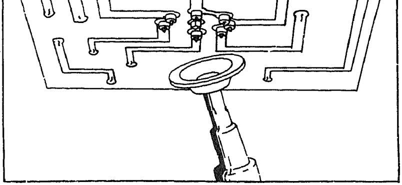
Mfg. Co. No. 9093), or a pocket penknife as illustrated in view B of figure 13.

The Ungar bar-type tiplet (Ungar No. 858) will remove straight-line multiterminal parts quickly and efficiently, as illustrated in view A of figure 14. Removal of this type of part may be accomplished by individually heating each solder connection and brushing away the melted solder with a wire brush (view B, figure 14). In using prevent loose solder from making contact with other parts or with the printed panel, where it may cause a possible short.

The Ungar cup-tiplets (Ungar Nos. 854, 855, and 856), the triangle tiplet (Ungar No. 861), and the hollow-cube tiplet (Ungar No. 863) are specially designed to withdraw solder from circular or triangular mounted parts in one operation. Refer to figure 15.

The most important technique required in the repair of modular assemblies is skill in soldering and unsoldering the parts. Careless work creates unnecessary damage. Take time and be precise!

In the application of solder, remember that the iron must heat the metal to the solder-melting temperature before actual soldering can



70.124D

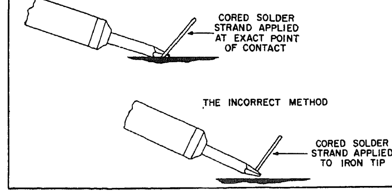
Figure 15.—Special soldering iron adaptions-cup-shaped tiplet method.

tip should be held directly against the parts to be soldered. The solder-melting temperature is reached in a matter of 5 to 10 seconds. Therefore, the soldering iron and the solder strand must be applied simultaneously. Apply the solder to the point of soldering iron contact, not to the soldering iron. Figure 16 illustrates both the correct and incorrect manner of solder application.

Be sure the terminal, lead, or any portion of a part to be soldered is properly cleaned and tinned before positioning it for soldering. Do not tin printed circuit terminals; just clean moisture, grease, or wax from the printed ribbon with a stiff bristle brush and methyl chloroform (GM-6810-00-664-0387) or alcohol.

Be sure the cleaning solvent is dry before applying the hot soldering iron. Alcohol is flammable and heating it increases its toxic hazard. Although the vapors of methylchloroform are much less toxic than carbon tetrachloride, they are still harmful. Carbon tetrachloride, gasoline, benzine, ether, or other like substances are NOT to be used for cleaning purposes. Methyl chloroform should be used only in a well-ventilated space; prolonged or repeated breathing of the vapor, or contact with the skin, should be avoided. Do not take internally.

Removal of a part without damaging the printed circuit board and its associated parts requires that the soldering tool be used with precision and skill. Thought should be given to the most appropriate procedure to use in the replacement of the affected part.



70.123A

Figure 16.—Correct and incorrect methods of solder application.

Defective Part Removal Procedures

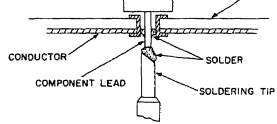
The following removal procedures are typical and should be applied in any applicable combination.

To remove a defective part, position the tip of a hot soldering pencil iron under and against the terminal, as shown in figure 17, to draw off the solder. The solder will flow to the soldering iron tip and is then removed from the tip by wiping it with a cloth. Remove as much of the solder as possible from each terminal. When all terminals are loosened, lift the part from the printed circuit board.

If the solder remains in the terminal holes after removing the leads, apply the soldering iron to the terminal hole and insert a toothpick or similar object to remove the softened solder.

Installing a New Part

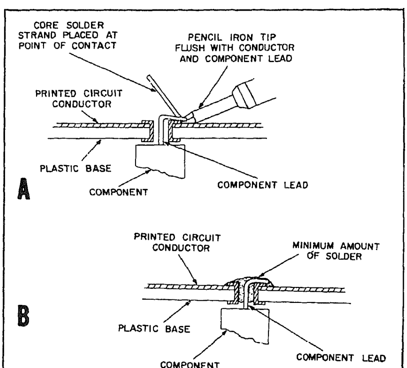
Before installing a new part, clean any moisture, grease, or wax from the area where the old part was removed. Use a short, firm-bristle brush and approved solvent (methyl chloroform). Be sure the cleaning solvent is dry before applying the soldering iron. Before installing the new part, preform and tin the leads. The new part should easily slip into position without placing a strain on the printed board terminals.



70.123B

Figure 17.—Correct method for removing solder from a component without damaging printed circuit wiring.

Position the new part firmly. Then, with diagonal cutting pliers, trim the leads to approximately 1/8 inch from the board terminal. Bend each trimmed lead over against the printed circuit conductor as shown in view A of figure 18. Using a minimum amount of solder (view B of figure 18), solder the leads to the printed circuit board terminal. Be careful to avoid overheating the printed board. This method assures a good contact with the printed circuit, and results in a rigid mounting which prevents the printed conductor from separating from the terminal.



70.123C

Figure 18.—Correct method for applying solder to a replacement component.

Although the troubleshooting procedures for printed circuits are similar to those for conventional circuits, the repair of printed circuits demands considerably more skill and patience. The printed circuits are small and compact and require special servicing techniques; thus personnel should familiarize themselves with the procedures.

PRELIMINARY PROCEDURES

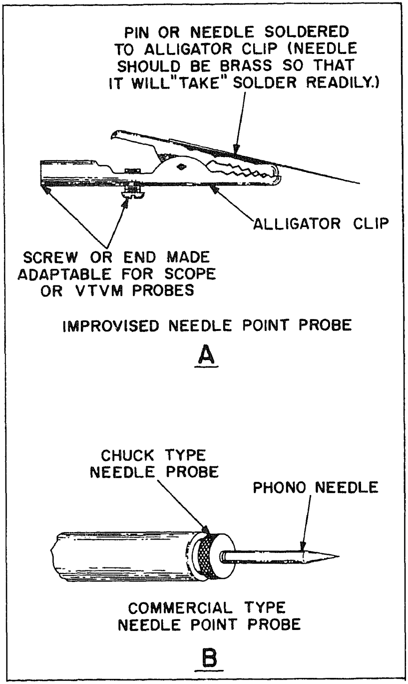
In all instances, it is advisable to check the defective printed circuit first before beginning work on it to determine whether any prior servicing was performed. Not all personnel having access to this type of equipment possess the requisite skill and dexterity; hence, preliminary inspection may reveal a flaw in a previous repair. By observing this precaution, you may save considerable time and labor.

Before attempting to trace a trouble on a printed circuit board, the defective part should be pinpointed by a study of the symptoms and by careful and patient analysis of the circuit. Ascertain whether the conducting strips are coated with a protective lacquer, epoxy resin, or similar substance. If so, carefully scrape it away; or better still, use a needle or chuck-type needle probe which will easily penetrate the coating for continuity checks. Types of needle probes are illustrated in figure 19.

Breaks in the conducting strip (foil) can cause permanent or intermittent trouble. Often, these breaks are so small that they cannot be detected by the naked eye. As seen in figure 20, hairline cracks (breaks) can be located only with the aid of a magnifying glass.

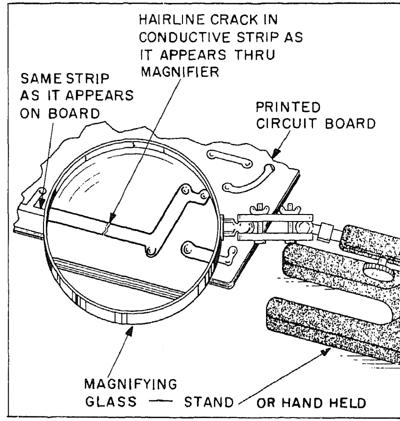
POINT-TO-POINT RESISTANCE TESTS

To check for and locate trouble in the conducting strips of a printed circuit board, set up a multimeter (one that does not pass current in



70.109

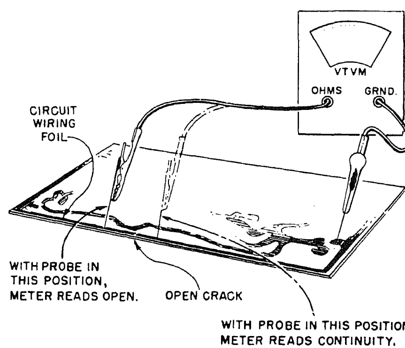
Figure 19.—Needle probes.



70.110

Figure 20.—Using a magnifying glass to locate a hairline crack.

excess of 1 milliampere) for making point-to-point resistance tests. (See figure 21.) Use needlepoint probes and insert one point into the conducting strip, close to the end or terminal, and place the other probe on the terminal or opposite end of the conducting strip. The multimeter should indicate continuity. If the multimeter indicates an open circuit, drag the probe along the strip until the multimeter in-



70.111

the area indicated, and then use a magnifying glass to locate the fault in the conductor.

CAUTION: Before using an ohmmeter for testing a circuit containing transistors or other voltage-sensitive semiconductors, check the current that it passes for each range. Do not use a range that passes more than 1 Ma.

BROKEN BOARDS

A broken board is probably the most difficult item of a modular assembly to repair. If the break is large, replacement of the entire board is usually the only practical solution.

Droppage is the most common cause of broken boards. Some boards are broken because of careless handling while the board is undergoing repair. Habitually observe the following precautions:

- Be extremely careful at all times while handling a board.
- Do not flex the board indiscriminately.
- Be especially careful when removing the board or replacing parts.
- Do not force anything associated with the board.

A printed circuit can be flexed to a certain extent. Flexing, however, may break the board, which then must be replaced at a considerable loss of time. To prevent this possibility, it is always a good policy to use a chassis-holding jig or vise when servicing printed circuit boards.

NOTE: When a board is broken, it is much better to replace the entire board rather than to repair it. The repair of printed circuit boards, therefore, is not covered in this chapter.

SERVICING TRANSISTORS

After working with vacuum tube equipment, you will find that maintaining and troubleshooting transistorized equipment present no new problems. Most transistorized equipments use printed circuits on which components are neatly arranged. This arrangement makes the transistors and other components easy to reach while troubleshooting and servicing. While investigating with test probes, however, you must be careful to prevent damage to the printed wiring.

One of the outstanding advantages of transistors is their reliability. Tube failures account for over 90 percent of the failures in electron tube equipments. Transistors, however, have long lives. This factor, among others decreases the amount of maintenance necessary to keep transistorized equipment operating. The techniques used in servicing transistorized equipment are similar to those for maintaining electron tube circuits. Basically, these techniques include the following:

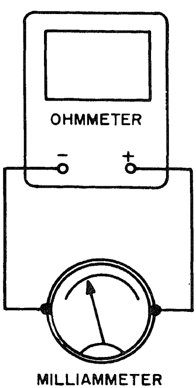
- Power Supply Check: As the first step in troubleshooting, you should check the power supply to see that its output voltages are present and of the correct values. Improper power supply voltages can cause odd effects. You will prevent many headaches by checking the power supply first.

- Visual Inspection: Visual inspection is a good maintenance technique. Occasionally, you may find a loose wire or faulty connection before extensive voltage checks are made.

- Transistor Check: Transistors, like electron tubes, can be checked by substitution. Transistors, however, have a characteristic known as leakage current which may affect the results obtained when the substitution method is used. The leakage current may influence the gain or amplification factor of the transistor. Thus, it is possible that a particular transistor will operate properly in one circuit and not in another. This characteristic is more critical in certain applications than in others. As the transistor ages, the amount of leakage current tends to increase. One type of transistor checker employed is the TS-1100/U Transistor Test Set. The TS-1100/U can be used either for in-circuit or out-of-circuit tests, or for collector leakage current or current gain.

● Voltage Check: Voltage measurements provide a means of checking circuit conditions in a transistorized circuit the same as they do in checking conditions in a tube circuit. The voltages, however, are much lower than in a tube circuit. The bias voltage between the base and emitter, for instance, is in the order of 0.05 to 0.20 volts; therefore, a sensitive VTVM is required. When making checks, polarity must be observed.

● Resistance Check: Transistors have little tendency to burn up or change value because of low voltage in their circuits. They can, however, be permanently damaged by high voltage conditions when the collector voltage is increased or when the ambient temperature increases and causes excessive collector current flow. Because transistors are easily damaged by high current, resistance measurements must not be taken with an ohmmeter having a maximum current output in excess of 1 Ma. If you are not sure that the ohmmeter range you want to use is below the 1-Ma level, connect the ohmmeter to a milliammeter and check it. See figure 22 for a method of measuring the current from an ohmmeter.



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Resistance measurements usually are not made in transistorized circuits except when being checked for open windings in transformers and coils. When a resistance check is required, the transistor must be removed from the circuit. Resistance checks cannot test all the characteristics of transistors, especially transistors designed for high frequencies or fast switching. The ohmmeter is capable of making simple transistor tests, such as open and short tests.

● Signal Tracing and Component Substitution: You can trace a signal through a transistor circuit in the same manner as you do in a vacuum tube circuit. When test facilities are available, this is often the fastest method for finding troubles in transistorized circuits. When the faulty component is located, replace it with a duplicate.

SERVICING DIODES

The major advantages of using diodes in a circuit are their smallness and the fact that they do not require heat to move electrons as in vacuum tubes. The main property of diodes is that they will pass current easily in one direction and only a small amount in the other direction. Because of this trait, diodes have been put to several uses in mixer, computer, noise limiting, and voltage-regulating circuits. Diode testers and tests are as varied as the diodes used.

Crystal diode tests are made most effectively under actual operating conditions. A common type of crystal diode test set is a combination ohmmeterammeter. Measurements of forward resistance, back resistance, and reverse current tests are made with this equipment. The condition of the diode under test is determined by comparing it with typical values obtained from test information provided with the test set or from the manufacturer's data sheets. A rough indication of a diode's reliability is provided by a front-to-back resistance check. Typical values for this test should provide a ratio of about 10:1 (front-to-back), and may indicate a forward resistance value of 50 to 80 ohms.

To test diodes used in computer circuits, it is

this purpose, a dynamic diode tester is used in conjunction with an oscilloscope. Diode characteristics such as flutter, hysteresis, and negative resistance can be easily interpreted by using this dynamic voltage-current display.

Voltage-regulating diodes (Zener) are also checked by the use of a dynamic tester in conjunction with an oscilloscope. This test develops signals that display the diode's reverse current versus voltage curve on the oscilloscope to determine the breakdown voltage, dynamic impedance, and noise characteristics. The purpose of this text is to determine the breakdown point, regulating ability, and the noise generated by the diode.

SERVICING INTEGRATED CIRCUITS

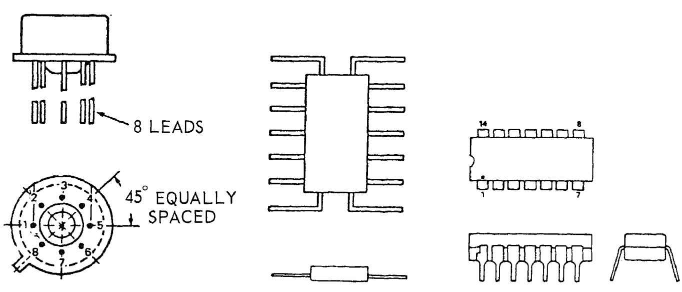
Over the past 30 years, microelectronic technology has provided rapid advances in the field of electronics. During this period, the electron tube, which was used in early electronic systems, has been virtually replaced by discreet solid state devices and integrated circuitry. Integrated circuits (ICs), in turn, have now given way to medium-scale and large-scale integrated circuitry.

Microelectronic technology today encompasses thin-film, thick-film, hybrid, and integrated circuits. These circuits (and combinations of them) are widely used in digital, analog, and other types of electronic circuits.

Integrated circuit packages have evolved from the still-used transistor type TO-5 style (modified to include more leads), to the flat pack design, to the dual-in-line package (DIP). Examples of the three package designs are shown in figure 23. Generally, these packages are limited to 14 leads, but some configurations are available with many more. Packages for the large-scale integrated (LSI) devices have been developed with up to 160 leads.

TROUBLESHOOTING INTEGRATED CIRCUITS

In most cases, several ICs will be mounted on a single printed circuit board. In many applications the printed circuit board will contain only ICs, while in other applications ICs will be mixed with discreet components such as transistors, capacitors, resistors, and so forth. Because most ICs are soldered to the boards, in-circuit troubleshooting procedures should be used before attempting to remove them, as the



TO STYLE

FLAT PACK

soldering and unsoldering of ICs.

As in transistor troubleshooting, IC troubleshooting should always begin with a check of the power supply voltages. This is normally a regulated voltage source that may range from about 4 to 12 volts. Caution should be observed while making the voltage check because the power supply may be capable of providing several amperes of current under short-circuited conditions.

After checking the power supply voltages, a visual inspection of the printed circuit boards should be made to check for faulty connections. This should be done only after power is removed from the equipment.

When remote testing facilities that will simulate normal operating conditions are not available, troubleshooting is best accomplished by board substitution and signal monitoring checks. After a faulty printed circuit board has been isolated, an oscilloscope can be used to isolate the problem to one or more components.

In digital ICs, troubleshooting is relatively simple because signal inputs and outputs are either in a high state or low state and the two states can be monitored on an oscilloscope. For example, in the Transistor-Transistor Logic (TTL) 7400 series IC, the power supply voltage is 5 volts and the low state output voltage ranges from approximately 0.0 to 0.8 volts. The high state produces an output ranging from 2.4 to 3.6 volts. When using an oscilloscope, it is best to use a probe with a needle probe tip rather than a probe with a retractable hook tip. This will prevent possible shorting of adjacent IC pins or leads when taking voltage measurements.

When the defective IC is located, the printed circuit board can be taken to the maintenance shop for repair. Before attempting to remove the defective IC, the board should be placed in a holding jig.

REMOVAL AND REPLACEMENT OF FLAT PACKS

Because of their small size and physical construction, extreme care must be exercised in soldering and unsoldering flat pack leads. Careless work can cause damage to the mounting surface, the IC, or both.

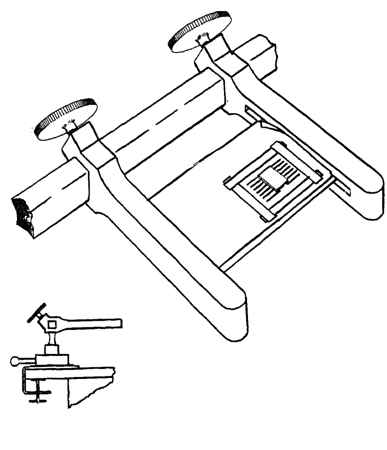
which it is mounted should be marked or a sketch made of the index point location so that replacement can be properly oriented.

The printed circuit board should be inserted into the card holder with the flat pack face up as shown in figure 24. If the flat pack has been covered with a protective coating (conformal coating), the coating may be removed by applying heat to the area to be cleaned and by gently scraping the coating away with an X-acto knife.

With a small pair of sharp chain-tip cutters, cut the flat pack leads halfway between the soldered joints and body of the flat pack.

If a thermal conductive adhesive has been used between the flat pack and the board, hold the device with tweezers and place the heated blade of an X-acto knife between the IC and the printed circuit board on the side of the IC. The knife should be gently moved back and forth in a cutting motion. This process should be performed on all four sides until the flat pack has been loosened.

After the IC has been removed, the leads should be unsoldered one at a time by the use of a desoldering iron with a solder sucker



249.50

Figure 24.—Printed circuit card holder.

attachment. The printed board should then be inspected with a magnifying glass. Next, remove all residue (conformal coating, solder flux, and solder splashes), and clean the board with a cotton swab that has been dipped in alcohol.

The replacement IC may require forming and lead trimming. If a suitable lead cutting and forming tool is not available, place the IC on a wooden block and cut the leads to the proper length, one at a time, with a sharp X-acto knife (figure 25).

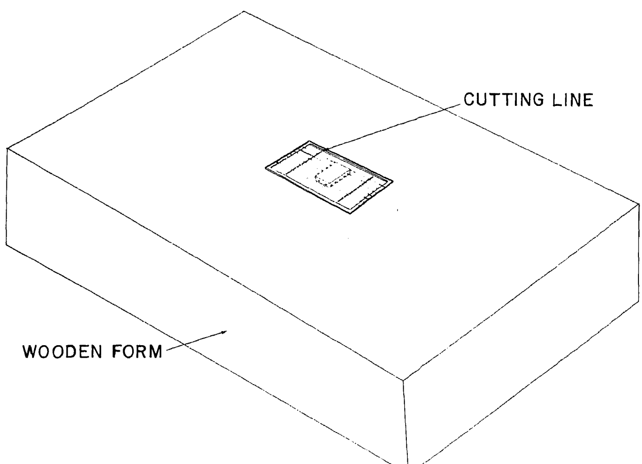
After you determine the proper orientation of the replacement IC, use a potting syringe and apply epoxy resin compound to the underside of the flat pack and place the package into position with a pair of tweezers. The adhesive should be allowed to cure before proceeding to the next step.

With a miniature low wattage iron, solder the flat pack leads, one at a time. Next, visually examine the area surrounding the replaced device for bad solder joints, bridging of solder between leads, flux residue, and excessive adhesive. Any residue should be removed with a cotton swab that has been dipped in alcohol.

If the system is available, place the printed circuit board in it for a final test and checkout. If the system is not available, the proper inputs should be duplicated in accordance with specified test procedures and the output monitored with bench test equipment and procedures in the appropriate equipment test and checkout manuals. If the circuit board is operating properly, the next and final step is to replace the conformal coating. (NOTE: This procedure is covered in section five of the EIMB, General Maintenance Handbook, NS-0967-LP-000-0100).

REMOVAL AND REPLACEMENT OF DIPs

All DIP packages have index points usually located in one corner or on the package



249.51

orientation.

When DIPs are coated with a conformal coating, this coating must be scraped away with an X-acto knife as previously described. Before the conformal coating between the IC and the printed circuit board can be removed, the IC leads must first be cut. As previously described for flat packs, DIPs must be loosened from the underlying conformal coating with a heated X-acto knife. After the IC is removed, the remaining conformal coating materials are removed.

Use a miniature soldering iron and a solder sucking attachment to remove the solder from each lead and then extract the lead with a pair of tweezers. The DIP holes can be cleaned by the use of a toothpick to remove the soft solder.

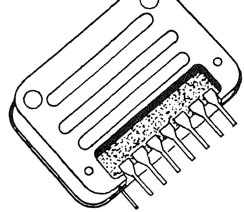
On printed circuit boards where a conformal coating is not used, DIP packages can be removed with the aid of a DIP package puller (figure 26). Solder should first be removed from the DIP leads at the top of the board with a solder sucker or wicking tool. Following this, the DIP extractor is placed over the ends of the IC and the IC leads heated simultaneously with a soldering tip designed for DIPs.

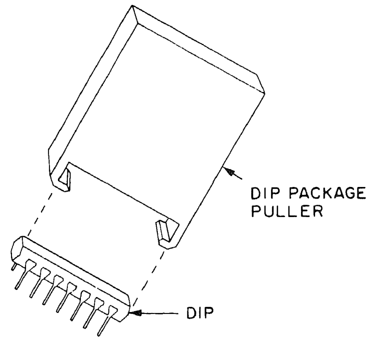
The replacement IC should be inspected prior to mounting. Insert the new DIP package in the board and solder the leads individually with a low wattage iron. After soldering, the area surrounding the DIP should be inspected for excess residue, poor solder joints, and bridging of solder between the leads. Corrective action, as necessary, should be taken to ensure that the IC is properly soldered into the circuit board and that the soldering is neat.

The printed circuit board should now be ready for system testing, or bench testing if the system is not available.

REMOVAL AND REPLACEMENT OF TO STYLE PACKAGES

Integrated circuit packages of the TO style generally contain 8 to 12 leads. The leads are usually arranged in a symmetrical pattern and mounted directly to lands on the printed circuit board. Two common mounting methods are





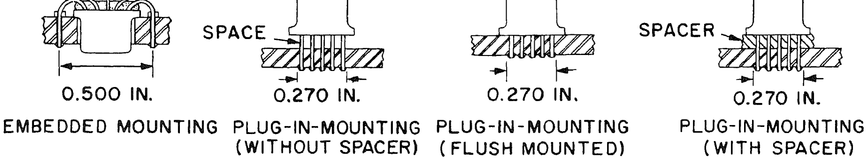
249.52

Figure 26.—DIP package puller.

used; an embedded method and a plug-in method. (See figure 27.)

The procedures currently used for removal and replacement of transistor TO packages also apply to the modified TO packages containing ICs. The major differences between the two are the number of leads and the spacing between the leads. On the IC package, this limits the space available for lead cutting, desoldering, and soldering, and requires that repair personnel have greater dexterity.

The index or reference point of a TO style package is usually a small metal tab that extends from the lip of the case. However, in some cases the case may be marked with a painted dot. The



249.53

Figure 27.—Embedded and plug-in mountings.

reference mark should be recorded before the device is removed.

After the protective coating has been removed, the device leads can be disconnected and the device removed. The removal procedure depends on the mounting method. If the package is embedded or plugged in without a spacer (figure 28), the leads should be cut and the IC removed before the remaining lead segments are unsoldered. If this is not possible, as in the case when the package is flush-mounted or plugged-in with a spacer, all leads must be simultaneously heated to allow the package to be removed. After the IC has been removed and the circuit board cleaned up, the new IC may be reinstalled. The new IC should be soldered in, one lead at a time. After soldering, the board should be inspected before being tested in the system or on the bench.

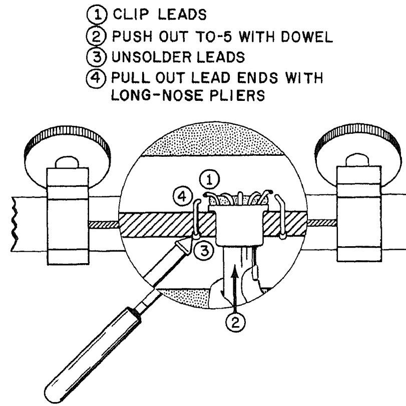


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Figure 28.—TO package removal (embedded).

TEST EQUIPMENT

Electronic test equipments are perhaps the most important of the tools the maintenance technician has to work with, for without them the job of troubleshooting and maintaining electronic equipment would be impossible. To have the required accuracy necessary to test modern electronic systems, many of the test equipment items you use are precision instruments and must be treated as such. To operate properly, test equipment must be handled with care and be operated only by knowledgeable and responsible personnel.

Rough handling, heat, moisture, and dust all affect the useful life of test equipment. Bumping or dropping a piece of test equipment may destroy the calibration of a meter, may destroy the meter movement itself, or may cause breaks or short circuits within the instrument's case. Sharp bends, creases, or dents in coaxial test cables can drastically alter the impedance and attenuating effect, and cause false readings or measurements to be taken. Forced cooling air, dust filters, and heaters are used in some test equipments to extend their useful life. These test equipments require a clean air filter for proper ventilation and a warmup period before the unit will hold calibration standards.

When not in use, electronic test equipment should be stowed in a dry place and with a dust cover. At a typical NAVFAC, most portable items can usually be stowed in one or more metal lockers. Inactive test equipment, after being certified, should be placed in stowage with a protective dust cover made of either plastic or polyvinyl. For ease in performing maintenance, the test equipment should be conveniently located near the equipment spaces. If possible, related test equipment should be stowed in the space where it is commonly used. In shipboard applications, test equipment stowage spaces should be equipped with retaining straps or belts to prevent the items from rolling or sliding on the stowage shelves.

OPERATING TEST EQUIPMENT

Only qualified personnel should be permitted to use test equipment for performing maintenance. In training maintenance personnel on the various equipment systems, the training should include instructions on the use of applicable test equipments.

The operators of test equipment should have a knowledge of the design and operating principles of the test equipment in use. Only the use of the exposed panel controls should be used for adjusting or setting up the equipment. This should entail setting calibrated dials to proper frequency and setting a pointer to zero on a meter, or to percent of modualtion, and so forth.

EVALUATION OF TEST EQUIPMENT

To evaluate test equipment for correct operation, the technician must know the proper way to use the equipment and be thoroughly familiar with its capabilities. Before using the test equipment, it should be checked if there is a doubt concerning its accuracy. If the technician cannot verify its operation by using equipment technical manuals, he should have the instrument checked by the test equipment calibration technician.

EQUIPMENT

Generally, the responsibility for repair and maintenance of test equipment is placed on maintenance personnel. In some cases, however, maintenance personnel are not authorized to make repairs and the test instrument must be sent to a shore repair/calibration facility.

When a test equipment item is capable of being qualified locally, the item is normally maintained and repaired locally. When a test instrument has failed, maintenance personnel should return the instrument to the qualification technician after it has been repaired and appears to be operating properly. The phase A and C qualification technician can inform maintenance personnel which equipments they are authorized to work on.

When test equipment is sent out for calibration and repair, all accessories, such as probes, adapters, calibration sheets, and so forth, should be included. Only in emergencies or special situations should partial repair or calibration be attempted on test equipment designated as non-repairable. Such emergency repairs should be noted on a tag attached to the unit and an entry made on the history card. The equipment should then be sent at the earliest opportunity to an authorized facility so that permanent repairs can be made and the unit calibrated.

Phase A and C Qualification Program

Qualification is a process by which test equipment is checked against a measurement device of a known or higher accuracy to assure that the instrument under qualification meets a predetermined specification.

The qualification segment of the Navy Calibration Program permits selected shore facilities and ships to be provided with the necessary calibration equipment and trained personnel to calibrate a certain number of their own high-volume, lower-accuracy test instruments. This Program provides the user more "inservice" time for his test equipment.

Test Equipment Safety Precautions

The electrical measuring instruments included in test equipment are delicately constructed and require certain precautions, when handled, to avoid damage and to ensure accurate readings. In addition, to avoid injury to personnel, there are other precautions that must be observed while using test equipment.

INSTRUMENT PRECAUTIONS

To avoid damage, there are three precautions that apply to all electric measuring instruments:

1. Avoid mechanical shock. Instruments contain permanent magnets, meters, and so forth, which are sensitive to shock. Heavy vibrations or shock can cause loss of calibration of these instruments.

2. Avoid exposure to strong magnetic fields. Strong magnetic fields may permanently impair the accuracy of an instrument by leaving permanent magnetic effects in the magnet of permanent-magnet, moving-coil instruments, in the iron parts of moving iron instruments, or in the magnetic materials used to shield instruments.

3. Avoid excessive current flow. This includes various precautions, depending on the type of instrument. When in doubt, use the maximum range scale on the first measurement and shift to lower range scales only after verifying that the reading can be made on a lower range. Connections should be made while the circuit is deenergized, if possible, and then all connections checked to ensure that the instrument will not be overloaded before reenergizing.

Precautions to be observed to avoid instrument damage include the following:

1. Keep in mind that the coils of wattmeters, frequency meters, and power meters may be carrying excessive current even when the meter pointer is on scale.

2. Secondaries of current transformers should never be open-circuited when the primary

3. Secondaries of potential transformers should never be short-circuited when the primary is energized.

4. Never leave an instrument connected with its pointer off-scale or deflected in the wrong direction.

5. Ensure that meters in motor circuits can handle the motor starting current. This may be as high as 6 to 8 times the normal running current.

6. Never attempt to measure the internal resistance of a meter movement with an ohmmeter, as the movement may be damaged by the current output from the ohmmeter.

7. Never advance the intensity control of an oscilloscope to a position which causes an excessively bright spot on the screen, or permit a sharply focused spot to remain stationary for any period of time.

8. In checking electron tubes with a tube tester that has a separate "short test", always make this test first. If the tube is shorted, no further test should be made.

9. Before measuring resistance, always discharge any capacitors in the circuit to be tested. Note and record any points not having bleeder resistors or discharge paths for capacitors.

10. Always disconnect voltmeters from field circuits or other highly inductive circuits before opening the circuit.

Situations can arise during the use of test equipment that are extremely dangerous to personnel. For example, you may have an oscilloscope plugged into one receptacle, an electronic meter plugged into another, and a soldering iron in still another. Also, you may be using an extension cord for some equipments and not others, or may be using other possible combinations. Some of the hazards presented by situations such as these include coming into contact with live terminals or test leads. In addition, cords

manner that a potential difference exists between the metal cases of the instruments and which may cause serious or fatal shocks.

Wires attached to test equipment should, if possible, extend from the back of the instruments away from the observer. If this is not possible, they should be clamped to the bench or table near the instruments.

When using instruments at locations where vibration is present, such as near a diesel engine, the instruments should be placed on pads of folded cloth, felt, or similar material.

Personnel Precautions

Precautions to be observed to avoid injury to personnel include the following:

- Ensure that the metal cases of all test instruments are properly grounded. Do not use VTVMs with metal cases for taking measurements on ungrounded power systems. The ground on a VTVM should be connected only to the ground or chassis of the equipment being checked. In multiple grounding systems, such as a NAVFAC's "Station" and "Base" signal and power ground systems, care must be exercised so that test equipment does not tie the grounds together.

- Ensure that one side of the secondary of external instrument transformers is also grounded.

- If equipment must be energized for testing after removal from its normal rack or mounting, ensure that all normally grounded points are securely grounded.

- Avoid testing voltages in excess of 300 volts when holding test probes with bare hands.

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OCEAN SYSTEMS TECHNICIAN 3 & 2 (MAINTAINER)

NAVEDTRA 062-02-45-88

Prepared by the Naval Education and Training Program Management Support Activity, Pensacola, Florida

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Congratulations! By enrolling in this course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program. You have taken an important step in self-improvement. Keep up the good work.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

ERRATA: If an errata comes with this course, make all indicated changes or corrections before you start any assignment. Do not change or correct the Training Manual (TRAMAN) or assignments in any other way.

TEXTBOOK ASSIGNMENTS: The TRAMAN for this course is Ocean Systems Technician Maintainer 3&2, NAVEDTRA 062-02-45-88. The TRAMAN pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions in the course. Pay close attention to tables and illustrations because they contain information that will help you understand the text. Read the learning objectives provided at the beginning of each chapter or topic in the text and/or preceding each set of questions in the course. Learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

BLACK DOT INFORMATION: Black dots (●) may be used in the text and correspondence course to emphasize important or supplemental information and to highlight instructions for answering certain questions. Read these black dot entries carefully; they will help you answer the questions and understand the material.

SELECTING YOUR ANSWERS: After studying the text, you should be ready to answer the questions in the assignment. Read each question carefully, then select the BEST answer. Be sure to select your answer from the subject matter in the TRAMAN. You may refer freely to the TRAMAN and seek advice and information from others on and from giving answers to anyone else taking the same course. Failure to follow these rules can result in suspension from the course and disciplinary action by the Commander, Naval Military Personnel Command.

SUBMITTING COMPLETED ANSWER SHEETS: It is recommended that you complete all assignments as quickly as practicable to derive maximum benefit from the course. However, as a minimum, your schedule should provide for the completion of at least one assignment per month--a requirement established by the Chief of Naval Education and Training. Failure to meet this requirement could result in disenrollment from the course.

TYPES OF ANSWER SHEETS: If you received Automatic Data Processing (ADP) answer sheets with this course, the course is being administered by the Naval Education and Training Program Management Support Activity (NETPMSA), and you should follow the instructions in paragraph A below. If you did NOT receive ADP answer sheets with this course, you should use the manually scored answer sheets attached at the end of the course and follow the directions contained in paragraph B below.

A. ADP Answer Sheets

All courses administered by the NETPMSA include one blank ADP answer sheet for each assignment. For proper computer processing, use only the original ADP answer sheets. Reproductions are not acceptable.

Recording Information on the ADP Answer Sheets: Follow the "MARKING INSTRUCTIONS" on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This

As you work the course, be sure to mark your answers in the course booklet because your answer sheets will not be returned to you. When you have completed an assignment, transfer your answers from the course booklet to the answer sheet.

Mailing the Completed ADP Answer Sheets: As you complete each assignment, mail the completed ADP answer sheet to:

Commanding Officer
Naval Education and Training
Program Management
Support Activity
Pensacola, FL 32559-5000

The answer sheets must be mailed in envelopes, which you must either provide yourself or get from the local Educational Services Officer (ESO). You may enclose more than one answer sheet in a single envelope. Remember, regardless of how many answer sheets you submit at a time, the NETPMSA should receive at least one a month. NOTE: DO NOT USE THE COURSE COMMENTS PAGE AS AN ENVELOPE FOR RETURNING ANSWER SHEETS OR OTHER COURSE MATERIALS.

Grading: The NETPMSA will grade your answer sheets and notify you by letter of any incorrect answers. The passing score for each assignment is 3.2. Should you get less than 3.2 on any assignment a blank ADP answer sheet will be enclosed with the letter listing the questions incorrectly answered. You will be required to redo the assignment and resubmit a new completed answer sheet. The maximum score that can be given for a resubmitted assignment is 3.2.

Course Completion: When you complete the last assignment, fill out the "Course Completion" form in the back of the course and enclose it with your last answer sheet. The NETPMSA will issue you a letter certifying that you satisfactorily completed the course. You should make sure that credit for the course is recorded in your service record.

Student Questions: Any questions concerning this course should be referred to the NETPMSA by mail using the address listed above or by telephone: AUTOVON 922-1366, or commercial (904) 452-1366.

B. Manually Scored Answer Sheets

If you did not receive ADP answer sheets with this course, it is being

Recording Information on the Manually Scored Answer Sheets: Fill in the appropriate blanks at the top of the answer sheet. This information is necessary for your course to be properly processed and for you to receive credit for your work. As you work the course, be sure to mark your answers in the course booklet, because your answer sheets will not be returned to you. When you have completed an assignment, transfer your answers from the course booklet to the answer sheet.

Submitting the Completed Manually Scored Answer Sheets: As you complete each assignment, submit the completed answer sheet to your ESO for grading. You may submit more than one answer sheet at a time. Remember, you must submit at least one assignment a month.

Grading: Your ESO will grade the answer sheets and notify you of any incorrect answers. The passing score for each assignment is 3.2. Should you get less than 3.2 on any assignment, the ESO will not only list the questions incorrectly answered but will also give you a pink answer sheet marked "RESUBMIT." You will be required to redo the assignment and complete the "RESUBMIT" answer sheet. The maximum score that can be given for a resubmitted assignment is 3.2.

Course Completion: After you have submitted all the answer sheets and have earned at least a 3.2 on each assignment, your command will give you credit for this course by making the appropriate entry on Page 4 of your service record.

Student Questions: Any questions concerning the administration of this course should be referred to your ESO.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 2 Naval Reserve retirement points. These points are creditable to personnel eligible to receive them under current directives governing retirement of Naval Reserve personnel.

COURSE OBJECTIVES

In completing this nonresident training course, you will be able to demonstrate a knowledge of the subject matter by correctly answering questions on the following: various publications used in electronic maintenance; the procedures for the proper care and upkeep of maintenance publications; station drawings; coding methods for electronic equipment; electrical diagrams and reference material used in electronic maintenance; trouble-shooting procedures for electronic equipment; techniques of testing and repairing subminiature transistors, diodes, modules, and printed circuits; factors concerning the use, repair, and measurement capabilities of test equipment used in electronic maintenance.

are not grouped by type but by subject matter. They are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Not all courses use all of the types of questions available. The student can readily identify the type of each question, and the action required, by inspection of the samples given below.

MULTIPLE-CHOICE QUESTIONS

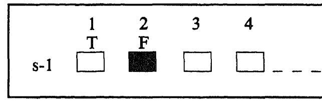
Each question contains several alternatives, one of which provides the best answer to the question. Select the best alternative, and blacken the appropriate box on the answer sheet.

SAMPLE

s-1. Who was the first person appointed Secretary of Defense under the National Security Act of 1947?

1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

Indicate in this way on the answer sheet:



TRUE-FALSE QUESTIONS

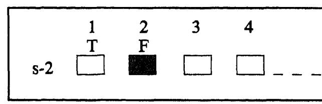
Mark each statement true or false as indicated below. If any part of the statement is false the statement is to be considered false. Make the decision, and blacken the appropriate box on the answer sheet.

SAMPLE

s-2. All naval officers are authorized to correspond officially with any systems command of the Department of the Navy without their respective commanding officer's endorsement.

1. True
2. False

Indicate in this way on the answer sheet:



MATCHING QUESTIONS

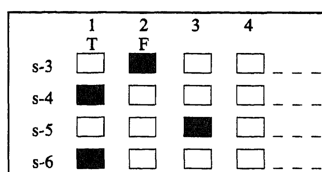
Each set of questions consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Items in column B may be used once, more than once, or not at all. Specific instructions are given with each set of questions. Select the numbers identifying the answers and blacken the appropriate boxes on the answer sheet.

SAMPLE

In questions s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions. Some responses may be used once, more than once, or not at all.

A. OFFICER	B. DEPARTMENT
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Disbursing Officer	3. Supply Department
s-6. Communications Officer	

Indicate in this way on the answer sheet:



Assignment 1

General Maintenance

Textbook Assignment: NAVEDTRA 062-02-45-88

Learning Objective: Identify the various publications used in electronic maintenance.

1-1. The most authoritative data for a specific equipment is provided in which of the following sources of information?
1. EIB
2. EIMB
3. Naval Shore Electronics Criteria Handbook
4. Technical Manual

1-2. Which of the following types of information is NOT found in a Technical Manual?
1. Parts Lists
2. Troubleshooting
3. Functional Discription
4. Maintenance History

1-3. An overview of the total Naval Shore Electronic System process is provided in which of the following publications?
1. EIB
2. EIMB
3. Technical Manual
4. Naval Shore Electronics Criteria Handbook

1-4. Which of the following statements best describes the Naval Shore Electronics Criteria Handbook series?
1. It is intended to be the single reference
2. It is designed as a source of pertinent criteria which are not promulgated elsewhere
3. It is designed as a ready reference to other related sources
4. Both 2 and 3 above

A. EIMB General Handbook

B. EIMB Installation Standards Handbook

C. EIMB Electronic Circuits Handbook

D. EIMB Test Methods and Practices Handboo

E. EIMB Reference Data Handbook

F. EIMB EMI Reduction Handbook

G. EIMB General Maintenance Handbook

Figure 1

IN ANSWERING QUESTIONS 1-5 THROUGH 1-11, SELE
THE PUBLICATION FROM FIGURE 1 WHICH CONTAINS
INFORMATION ON THE SUBJECT USED AS THE QUESTI

1-5. Circuit measurements.
1. B
2. C
3. D
4. E

1-6. Parts identification referencing.
1. B
2. C
3. D
4. E

1-7. Soldering, welding, and brazing.
1. A
2. B
3. C
4. D

1-8. Failure analysis of a power supply.
1. B
2. C
3. D
4. E

1-9. Safety, administrative procedures, and an index to EIB articles.
   1. A
   2. B
   3. C
   4. D

1-10. Procedures for eliminating electromagnetic interference.
   1. D
   2. E
   3. F
   4. G

1-11. Equipment-level and system-level maintenance philosophies.
   1. D
   2. E
   3. F
   4. G

1-12. Which of the following types of information is found in the EIB?
   1. SCAT codes
   2. Allowance parts lists
   3. Cross reference parts list updates
   4. Advance information of field changes

1-13. Corrective maintenance and equipment problems reported for a particular month by all NAVFACs are published in which of the following information sources?
   1. EIB
   2. NAVSHIPS Technical Manual
   3. NAVSEA Technical News
   4. WECO Monthly Engineering Report

Learning Objective: Identify the procedures for the proper care and upkeep of maintenance publications.

1-14. The directions and authority to make an interim change to a technical publication are usually received by the NAVFAC in the form of a/an
   1. change transmittal letter
   2. EIB article
   3. supplemental manual
   4. notice from NAVSHIPS

1-15. When you order a technical manual that you know has been revised, which of the following actions should you take?
   1. Ensure that you use the new stock number
   2. Use the same stock number as the superseded edition

1-16. A technical manual is normally revised when which of the following conditions exists?
   1. When the original supply stock is depleted
   2. When the original has numerous pen-and-ink changes
   3. When permanent change pages exceed 25 percent of the manual
   4. Each of the above

1-17. How can you determine what changes have been entered in a Technical Manual?
   1. By referring to the Letter of Promulgation
   2. By referring to the "Record of Corrections" page
   3. By checking the date of revision
   4. By checking the "Title" page

Learning Objective: Identify the uses of station drawings.

1-18. What is the station drawing series number for station 102W?
   1. T-102-000
   2. T-202-000
   3. T-000-102
   4. T-000-202

1-19. The floor plan of the terminal equipment building is shown on which of the following station drawings?
   1. T-1XX-005
   2. T-1XX-010
   3. T-1XX-200
   4. T-1XX-500

To answer questions 1-20 through 1-22, select from column B the title for the drawing number in column A.

	A. Drawing Number	B. Title
1-20.	T-150-XXX	1. Station Drawing Record
1-21.	T-1XX-000	2. General-use Drawings
1-22.	T-250-XXX	3. Assembly Drawings
		4. Manufacturer's Drawing Record

1-23. After an equipment installation or modification, how many sets of drawings are usually provided to the station?
   1. One

Learning Objective: Identify coding methods for electronic equipment.

1-24. What is the designator for the parent equipment of the TD-494/FQA-4(V)?
1. AN/FQA-4(V)
2. AN/FQA-494
3. AN/TD-494
4. AN/TD-4(V)

1-25. You are working on a system made up of modular unit construction. The reference designation 5A1A2C3 refers to what equipment part?
1. The second capacitor of subassembly 5A1A of unit 3
2. The fifth capacitor of subassembly A1A2 of unit 3
3. The third capacitor of subassembly A1A2 of unit 5
4. The fifth capacitor of subassembly A1A2 of unit C3

1-26. On a schematic diagram, how is pin 5 of relay K13 designated?
1. 5-XK13
2. 13XK-5
3. XK5-13
4. XK13-5

Learning Objective: Identify the electrical diagrams and reference material used in electronic maintenance.

1-27. When installing a field change in an amplifier that requires replacement of a coupling capacitor, what diagram is the most useful?
1. Functional block
2. Manufacturer's blueprint
3. Schematic
4. Wiring

1-28. If you want to analyze the electronic theory of a component or a group of components and determine how they function in a particular circuit, what is the best diagram to use?
1. Functional block
2. Internal functional block
3. Wiring
4. Schematic

Learning Objective: Recognize troubleshooting procedures for electronic equipment.

1-29. Symptom elaboration is the troubleshooting procedure that you use to obtain which of the following results?
1. Information about the test equipment required to repair the equipment
2. A list of the functional units in the equipment
3. Voltage and resistance readings in the suspected faulty circuit
4. More information about the symptom

1-30. When a trouble symptom has been recognized, why should the appropriate controls and switches on the equipment be manipulated?
1. To check for a possible maladjustment of the controls and to observe the effect that adjusting the control has on the operation of the equipment
2. To check for a possible maladjustment of the controls and to identify the purpose of each control knob
3. To locate each functional unit on the equipment diagrams
4. To determine whether to eliminate steps 3 and 4 from the troubleshooting procedure

1-31. When localizing the faulty function, the test equipment should be used to
1. test each tube in the suspected unit
2. check the input and output signals of the suspected units
3. check the input signal in the suspected unit and the a.c. power to the equipment
4. test components in the suspected circuits

1-32. As used in troubleshooting, "bracketing" is a procedure that allows you to
1. isolate a trouble between a satisfactory input signal and a faulty output signal
2. inject a test signal and evaluate a suspected circuit
3. divide the suspected units according to size
4. begin at the output of a unit and check, circuit by circuit, toward the input

Learning Objective: Recognize techniques of testing and repairing subminiature transistors, diodes, modules, and printed circuits.

1-33. An advantage of modular construction over wired circuits in electronic equipment is described in which of the following statements?
1. Less skill is required to service them
2. They can be repaired faster
3. They are more compact and reliable
4. Each of the above

In items 1-34 through 1-36, select from column B the subminiature electronic construction term that is defined in column A.

A. Definitions	B. Terms
1-34. Several parts or any combination of parts joined together to perform a specific function	1. Module
	2. Assembly
	3. Unitized Construction
1-35. A unit or standard of measurement	4. Modular assembly
1-36. An assembly having outlined dimensions	

1-37. When it is necessary to solder subminiature assemblies, what is the purpose of a heat sink?
1. To protect the circuit board
2. To allow the solder to melt more rapidly
3. To protect the component being soldered from excess current flow
4. To protect the component being soldered from excess heat

1-38. When you repair a board of a modular assembly, you should use (a) what type of soldering iron and a solder with (b) what type of core?
1. (a) light-duty (b) rosin
2. (a) light-duty (b) acid
3. (a) heavy-duty (b) rosin
4. (a) heavy-duty (b) acid

1-39. You are soldering a silver circuit connection on a modular board. Which of the following solder combinations should be used to solder the connection?
1. 60% tin and 40% lead
2. 63% tin and 37% lead

1-40. Which of the following actions may cause a high transient current or voltage in a modular circuit?
1. Connecting a piece of a.c. power-operated test equipment without an isolati transformer
2. Connecting a piece of test equipment to a circuit having a low-impedance path
3. Disconnecting parts, inserting or removing components, and changing modular units with equipment power on
4. Each of the above

1-41. You are attempting to make emergency repairs on a module, but a low-wattage pencil soldering iron is not available. What emergency measure should you take to convert a high-wattage iron to a low-heat unit?
1. Put a heavy coating of solder on the tip of a high-wattage iron
2. Wire a 10K ohm resistor in series with one side of the high-wattage iron supply lines
3. Wrap a clean piece of number 10 copper wire around the high-wattage iron tip and extend it one inch beyond the tip
4. All of the above

1-42. After heat is applied, how much time is required for solder to reach its melting temperature?
1. 5 to 10 sec
2. 10 to 20 sec
3. 20 to 30 sec
4. 30 sec to 1 min

1-43. Prior to soldering a transistor to a printed circuit board, which of the following preliminary actions must you take?
1. Clean and tin the transistor leads and printed circuit terminal
2. Clean and tin the printed circuit terminal and clean the transistor leac
3. Clean both the printed circuit termina and the transistor leads
4. Clean the printed circuit terminal anc clean and tin the transistor leads

1-44. When a replacement part is installed, how close to the circuit board should the leac be trimmed?
1. 1/8 in.
2. 1/4 in.
3. 3/8 in.
4. 1/2 in.

45. What is the fastest way to detect a break in the conducting strip of a printed circuit board?
    1. Visual inspection with a magnifying glass
    2. Signal tracing with a multimeter
    3. Signal tracing with an oscilloscope
    4. Continuity check with an ohmmeter

46. To locate a trouble in the conducting strip of a printed circuit, set up a multimeter that will NOT pass current in excess of (a) how many milliampres then make (b) what type of check?
    1. (a) 0.5 (b) voltage
    2. (a) 1.0 (b) continuity
    3. (a) 0.5 (b) continuity
    4. (a) 1.0 (b) voltage

47. In servicing a piece of transistor equipment, what should be the first step?
    1. Resistance check
    2. Transistor check
    3. Visual inspection
    4. Power supply check

Question 1-48 should be judged True or False.

48. As a transistor ages, the amount of leakage current tends to increase.

49. You are using a crystal diode test set under actual operating conditions to test the forward and back resistance of a diode. What additional characteristic of the diode can be determined accurately with this test set?
    1. Reverse current
    2. Hysteresis
    3. Dynamic impedance
    4. Generated noise

50. You are using a dynamic diode test set in conjunction with an oscilloscope to test diodes in a computing circuit. What diode characteristics can be interpreted by this dynamic voltage-current display?
    1. Dynamic impedance and regulating ability
    2. Breakdown point and negative resistance
    3. Regulating ability and noise characteristic
    4. Flutter, hysteresis, and negative resistance

1-51. A dynamic tester is used in connection with an oscilloscope to check voltage-regulating diodes (Zener). The purpose of this test is to determine the
    1. forward resistance, back resistance, and reverse current of a diode
    2. flutter, hysteresis, and negative resistance of a diode
    3. breadown point, regulating ability, and the noise generated by a diode
    4. forward resistance, negative resistance, and the breakdown point of a diode

1-52. Usually, ICs are limited to how many leads?
    1. 8
    2. 14
    3. 24
    4. 160

1-53. As a rule, when troubleshooting solid state circuits, you should first
    1. visually inspect the printed circuit connections
    2. check the input voltages
    3. substitute plug-in modules with known good modules
    4. check the continuity of the printed circuit

1-54. When you remove polyurethane conformal coating from a flat pack, you should scrape the coating away after
    1. cleaning the area with alcohol
    2. heating the area with a soldering iron
    3. soldering all the leads
    4. removing the solder

1-55. To avoid stress on the integrated circuit, the leads should be cut with
    1. an IC cutting and forming tool
    2. diagonal pliers
    3. scissors
    4. an x-acto knife

1-56. After placing an IC on a printed circuit board, any residue left on the area that was worked on should be cleaned with
    1. warm soapy water
    2. carbon tetrachloride
    3. a stiff wire brush
    4. alcohol

1-57. Prior to removing a TO-5 package from a circuit board, the leads should be cut if the package is mounted by what type of method?
    1. Flush-mounted
    2. Plug-in with spacer
    3. Imbedded

Learning Objective: Recognize factors concerning the use, repair, and measurement capabilities of test equipment used in electronic maintenance.

1-58. Why is it necessary to allow some test equipments a warmup period?
1. To stabilize all calibration standards
2. To ensure all capacitors have sufficient time to discharge
3. To compensate for coaxial attenuation
4. To dry out moisture within the test equipment

1-59. Before you permit a person to use a piece of test equipment, what minimum requirement should he meet?
1. Be a graduate of a formal test equipment school
2. Understand every possible use of test equipment
3. Have a complete knowledge of internal and external calibration techniques
4. Understand the design and operating principles of the test equipment

1-60. How does a phase C calibration technician check the accuracy of a piece of test equipment?
1. By checking all the internal power supplies with an accurate volmeter
2. By checking all the test points in accordance with the technical manual
3. By measuring circuits for which the voltages and current values are already known
4. By checking it against a standard of known accuracy

1-61. The purpose of the phase A and C qualification segment of the Navy Calibration Program is to
1. provide greater accuracy for all test equipment
2. allow selected stations to calibrate their own test equipment
3. provide more inservice time for the high-volume, critical test equipment
4. provide more inservice time for the most frequently used low-accuracy test equipment

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